OPERATING MANUAL

105

NOISE/COM

A Wireless Telecom Group Company

OPERATING MANUAL

Technical Manual

Model MP-2500
Multipath Fading Emulator

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Section 1. General Information

1.1 Overview of the Multipath 2500 Fading Emulator

The Multipath 2500 Fading Emulator (MP-2500) emulates a wireless communication channel with propagation over as many as 12 reflected signal paths between one or two base stations and a mobile transceiver. The MP-2500 is illustrated in Figure 1-1. The MP-2500 system includes an embedded 486DX/33 microprocessor and PC-compatible IEEE 488.2 and ISA interfaces. The MP-2500 is self-contained and easily transportable. An 88-key keyboard and flat panel color display make the MP-2500 an extremely powerful tool.

Principal applications for the MP-2500 include:

- Personal Communication Service (PCS)
- Global System Mobile (GSM/DCS 1800)
- Paging
- Digital European Cordless Telephone (DECT)
- Personal Handy-Phone/Japanese Digital Cordless Telephone (PHP/JDCT)
- Wireless LAN (WLAN)
- Digital TV (HDTV)

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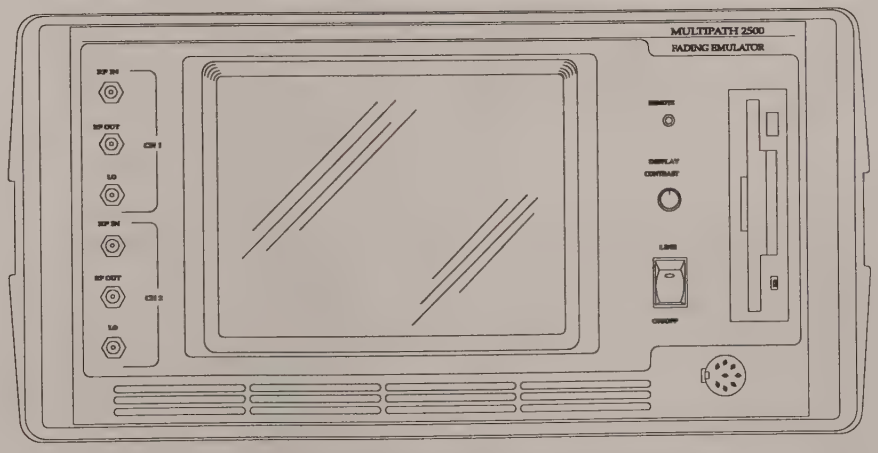

Figure 1-1. MP-2500 Multipath Fading Emulator

- Cordless Telephone 2 (CT-2)
- North American Digital Cellular (NADC/IS-54)
- Code Division Multiple Access (CDMA)(IS-97/98)
- Time Division Multiple Access (TDMA)(IS-55/56)
- Space diversity testing
- Radar target emulation

1.2 Features and Functions

The principal features and functions of the MP-2500 include:

- *Doppler Fading Emulation.* The differential path delay, path attenuation, phase shift, and Doppler shift are individually programmable for each of the reflected signal paths. The signals in all paths are summed together at the MP-2500 output to emulate the multipath signals arriving at the receiver antenna. This summation of multiple signals with random phase causes random amplitude fluctuations, or fading.
- *Flexible Input Modes.* The User can input information directly to the MP-2500 using the built-in keyboard and monitor, or with any standard personal computer equipped with an IEEE-488 interface port.
- *Multiple Path/Channel Combinations.* The MP-2500 is automatically reconfigurable to perform single channel tests with up to 12 paths, or dual channel tests with up to 6 paths per channel. In addition, the instrument may be configured to perform forward/reverse links, diversity, interference, and duplex testing, without the use of external power dividers or combiners.
- *Choice of Operating Modes:*

  Static Mode. The User sets the desired parameters individually into each path. Standard test conditions for GSM, DCS, NADC/CDMA, and other applications are factory stored and can be recalled readily. Using the *Live Data* capability, path parameters can be modified according to a user generated ASCII data file. The MP-2500 can import and run a file containing either field strength or impulse response data.

  Dynamic (Graphic) Mode. A graphical representation of two base stations, a mobile transceiver, reflectors, and an RF shadow is used to emulate a multipath environment containing these objects. The MP-2500 updates Doppler, delay, and path attenuation in real time. A choice of one or two base stations is available to perform forward/reverse link testing, including the effects of co-channel and adjacent channel interference.

- *Full Band Frequency Coverage*: 800 - 2500 MHz (DC to 6000 MHz, in multiple bands; optional)
- *Choice of Fading Statistics:* Rayleigh, Rician, Log-Normal, Suzuki, Nakagami
- *Adjustable Delay Interval:* 216 µsec with 1 nsec resolution
- *Highly Accurate Processing*: 12-bit A/D converter resolution
- *Spurious free output:* -55 dBc spurious; -75 dBm LO leakage

1.3 Options and Optional Configurations

Table 1-1 describes the options available with the MP-2500.

Table 1-1. MP-2500 Options

Option	Description
1	Factory installed upgrade from MP-2500-3 to MP-2500-6.
1S	Factory installed upgrade from MP-2500-3 to MP-2500-6S.
2	Factory installed upgrade from MP-2500-6 to MP-2500-12.
3	19" rack mount. Includes brackets and front plate. Not available with Option 6.
4	External input attenuator. Changes input power range to: +13 to +43 dbm (See 1.5 High Power Attenuator Specifications).
5	Duplex signal interface for direct connection to the antenna port of a mobile phone. The interface separates the TX and RX signals and provides isolation between the two channels. The frequency range is 800 to 2500 MHz.
6	18" wide chassis (instead of standard 14" chassis). Contains 4 additional ISA slots. Available only if specified with initial order.
7	Frequency range. Several frequency ranges in the band between 30 MHz and 6 GHz are available. Consult factory.
8B	Synthesized local oscillator: 120 to 2640 MHz. Consult factory for frequency coverages. Requires/includes Option 6.
9	I/Q interface.
L	30 - 2000 MHz frequency range.

1.4 Specifications

1.4.1 Baseline MP-2500 Multipath Emulator

The performance specifications, physical dimensions, and power requirements for the MP-2500 are listed in Table 1-2.

Table 1-2. MP-2500 Specifications

Frequency range	
Baseline	800 to 2500 MHz
Option "L"	30 to 2000 MHz
RF input power range	
Baseline	-10 to + 20 dBm, with 54 dB SNR
	Usable to -64 dBm
Option	+13 dBm to + 43 dBm, with 54 dB SNR
RF output power range	
Baseline	-19 to -100 dBm
Number of paths (user programmable)	Up to 12 (MP-2500-12)
RF Bandwidth (3 dB)	6.0 MHz, typical
Attenuation accuracy	±0.2 dB
Amplitude ripple	±0.2 dB from best-fit straight line
Path attenuation range	0 to 30 dB
Path attenuation resolution	0.017 dB
Path-path amplitude balance	±0.2 dB, maximum
Path on/off ratio	65 dB, minimum
S/N ratio at output > -34 dBm	54 dB per 6 MHz bandwidth
Spurious output	-55 dBc or -85 dBm, whichever is greater
Path-to-path delay range	0 to 216 µs
Delay resolution	1 ns
Path-to-path delay accuracy	±5 ns, maximum
Group delay variation	±30 ns, typical
Residual channel delay	2.6 µs, typical
Doppler range	
Baseline	0 to ±780 Hz
Option	0 to ±1560 Hz (1 to 3 paths, only)
Doppler resolution	0.0156%

Table 1-2. MP-2500 Specifications *(continued)*

Rayleigh distribution		
Repetition interval (programmable)	From 1 second to 24 hours, minimum	
Deviation from CPDF	±0.5 dB, maximum, from -25 to +10 dB	
Level crossing rate accuracy	±2.5%	
Path-to-path correlation	0 to 100%	
Correlation resolution	1%	
LO input frequency range	RF frequency plus 140 MHz	
LO input level	+13 dBm, nominal	
LO feedthrough on RF output	-95 dBm, typical	
Image feedthrough on RF output	-60 dBc, maximum	
Internal processor and peripherals		
486DX/33 MHz	4 MB RAM	Mouse
VGA display	88-key keyboard	Serial port
3.5" floppy drive	420 MB hard drive	
IEEE-488.2 interface	Parallel/printer port	
RF input/output connectors	50 ohms SMA female	
Input VSWR	1.8:1, maximum	
Output VSWR	1.5:1, maximum	
Primary power		
Voltage	90 - 264 VAC, autoranging	
Frequency	48 - 66 Hz	
Consumption	300 VA, maximum	
Fuse	4A, slow-blow	
Operating temperature range	0°to 50°C	
Instrument safety	UL-1244, CSA 231, IEC-1010-1	
EMC	EN55011, Group 1, Class A*	
Dimensions	455 mm D x 364 mm W x 197 mm H (17.9 in D x 14.3 in W x 7.8 in H)	

*All signal and control cables connected should not exceed 3 meters (9 feet) in length.

1.4.2 Specifications for Option 4: High Power Attenuator

Frequency range	DC to 8 GHz
Nominal attenuation	20 ±0.3 dB
Maximum VSWR	1.20:1 into 50 ohms
Power rating	25 watts average to 25°C derated to 2.5 watts @ 125°C 5 KW peak, 5 µsec pulse, 0.25% duty cycle
Temperature coefficient	0.0004 dB/dB/°C
Power coefficient	0.0006 dB/dB/watt
Connectors	Type N female
Weight	170 grams
Physical dimensions	See Figure 1-2.

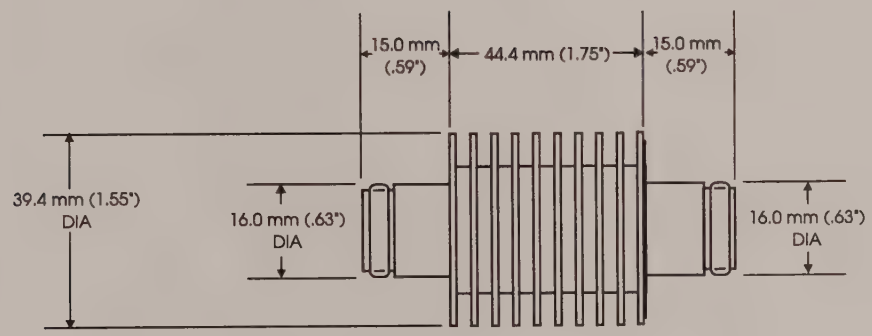

Figure 1-2. High Power Attenuator

1.4.3 Specifications for Option 5: Duplexer

Channels	Two independent duplex channels. Each channels supports two frequency bands.
Frequency range	800 to 1300 MHz 1300 to 2500 MHz
Isolation	
Minimum	15 dB
Typical	20 dB
Insertion loss	1 dB, maximum
Maximum VSWR	1.5:1
Connectors	
Duplex ports	Type N female
Uni-directional ports	SMA female
Dimensions	368.0 mm W x 120.6 mm H x 425.5 mm D (14.5" W x 4.75" H x 16.75" D)

1.4.4 Specifications for Option 8B: Synthesized Local Oscillator

Frequency range	120 MHz to 2640 MHz
Frequency resolution	1 MHz
Phase jitter	<1°RMS, 10 Hz to 100kHz, single sideband
Output Power	+10 dBm, minimum
Power at Sample output	-20 dBm, typical
Spurious outputs	-60 dBc @ F_C ±10MHz
Harmonics	-10 dBc, maximum
Power consumption	250 watts per synthesizer
Input line voltage	Selectable from 100 VAC to 240 VAC, 50-60 Hz
Dimensions	368.0 mm W x 120.6 mm H x 425.5 mm D (14.5" W x 4.75" H x 16.75" D)

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Addendum to MP2500/MP2600 operating manual and service manual

I/Q Interface (option 9) Specifications and Connection Instruction

Specifications

Input frequency:	DC to 13 MHz
Input power:	0 dBm (0.63 Vpp) per input
Output power:	-24 dBm (0.16 Vpp) per output
LO feedthrough:	-54 dBm per output
Image suppression:	30 dBc
Harmonics:	50 dBc
Amplitude balance:	+/- 0.25 dB DC to 3 MHz
	+/- 0.5 dB DC to 13 MHz
Phase balance:	+/- 4 degrees DC to 13 MHz
In/out impedance:	50 ohms nominal
Connectors:	BNC female

Connection

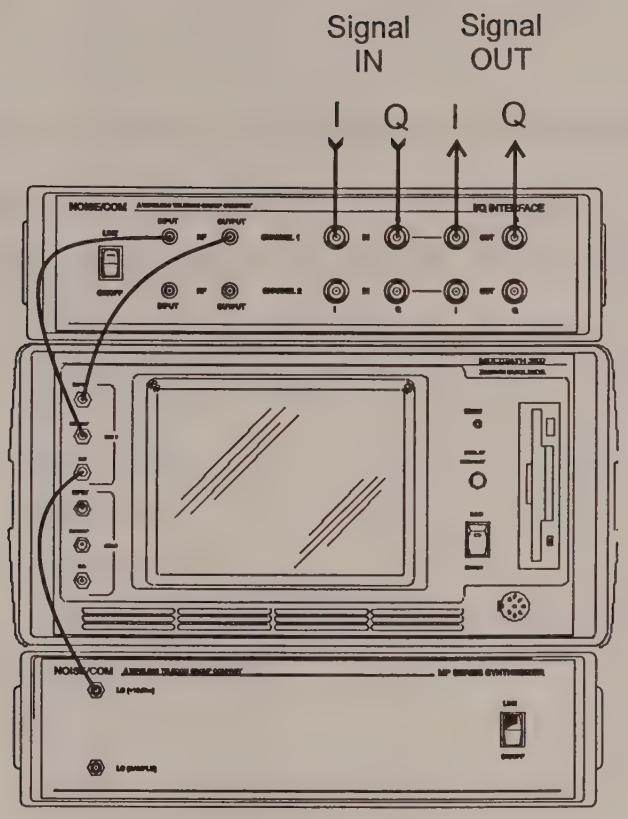
1. Refer to diagram on next page. The diagram shows the connection made to one channel only. If you have a two channels, repeat the same wiring configuration for channel 2.

2. The I/Q signal "IN" ports connect to the baseband I and Q signal source; the "OUT" ports connect to the I and Q ports of the device under test.

3. The RF output of the I/Q interface connects to the input port of the MP2500/MP2600. The RF input of the I/Q interface connects to the output port of the MP2500/2600. The LO port of the MP2500/2600 connects to the synthesized LO (option 8B).

Applications

To use the I/Q interface, make sure that the center of the input frequency of the MP2500/2600 is set at 820 MHz. Set the output power of the MP2500/MP2600 to -30 dBm. Click on "START" to turn on multipath fading.



Interconnect diagram of MP2500/MP2600, I/Q interface (option 9) and Synthesized LO (Option 8B).

Section 2. Installation

2.1 Unpacking

Carefully remove the MP-2500 from the shipping container. Retain the shipping container for future use.

The standard materials shipped with the MP-2500 include:

MP-2500 chassis

Power cord

Serial mouse

Technical manual

Documentation for National Instruments IEEE-488 interface

Optional materials include:

Rack Mount Kit

Duplexer

High Power Attenuator

Synthesized Local Oscillator

2.2 Initial Inspection

Inspect the shipping container for damage. If the container is damaged, retain it until the contents of the shipment have been verified against the packing list and the instrument has been inspected for mechanical and electrical operation.

If the instrument has been damaged in transit, notify both the carrier and Noise Com, Inc.

2.3 Interconnections

2.3.1 Power Connections

Connect the power cord furnished with the MP-2500 to the AC input connector on the rear of the chassis and to a grounded power source of the proper voltage.

2.3.2 RF Connections

Both the input and output RF connectors are located on the MP-2500 front panel.

1. Connect the RF source to the SMA-female RF input connector.
2. Connect the receiver under test to the SMA-female RF output connector.
3. Connect the LO signal source to the LO input of the appropriate channel.

2.3.3 GPIB Connections

Connect the IEEE 488-2 interface cable to the mating connector on the rear panel. The IEEE 488-2 interface connector is located in expansion Slot 3. Tighten the retaining screws on the cable connector.

NOTE *Signal and control cables should be no more than 3 meters (9 feet) long.*

2.3.4 External Mouse and Monitor

Connect the external mouse to the bottom 9-pin connector in Slot 4 on the rear of the instrument. Slot 1 is nearest the 120 VAC connector. (See Figure 3-3.)

A VGA monitor may be connected and operated simultaneously with the built-in display. The VGA connector is in Slot 2 on the rear of the instrument. (See Figure 3-3).

NOTE *The mouse and monitor must be connected before you turn on the MP-2500.*

2.4 Turn On

1. Press the *On* button on the MP-2500 front panel.
2. The opening logo screen will appear after approximately 30 seconds.
3. Click the left mouse button on *New Static File*.
4. The parameter table for the *Static* mode should appear.

If the appropriate parameter table does not appear after you have performed these steps, contact Noise Com Technical Support.

2.5 Performance Verification

Refer to the *Service Manual for the MP-2500 Multipath Emulator* for the recommended procedures for verifying the operation and performance of the MP-2500.

Section 3. Operation

3.1 Getting Started

3.1.1 Starting Point

After the MP-2500 is powered on, the main display will appear (Figure 3-1). The MP-2500 has two modes of operation, the *Static* mode and the *Dynamic* mode. These modes are explained later in this section. The selections you will see when you turn on the MP-2500 include:

1. Create a *New Static* file
2. Create a *New Dynamic* file
3. *Open* an existing *Static* file
4. *Open* an existing *Dynamic* file
5. *Help*
6. *Exit*

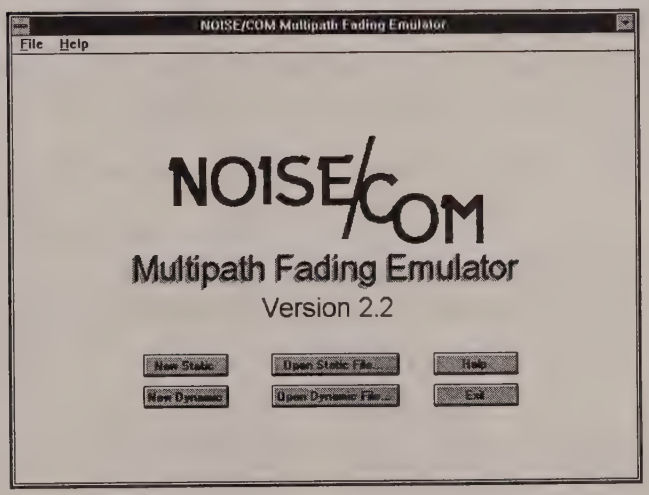


Figure 3-1. MP-2500 Main Display

Use the mouse to make your selection. Alternatively, use the *Tab* key to select a function and press *Enter*

The *Static* mode enables you to set all path parameters and store them in files. Subsequently, *Static* files can be run with preset parameters. Many of these parameters can be updated while the file is running. The *Dynamic* mode automatically modifies path parameters in real time according to the physical locations and properties of objects that have been placed on a two-dimensional map.

3.1.2 Using the Mouse and Keyboard

You may use the mouse, keyboard, or a combination of the two to operate any of the MP-2500 controls on any of the parameter display screens.

1. Operating the MP-2500 with the Mouse

Click the left mouse button once to activate any of the buttons or scroll bars. The following functions are performed by double-clicking the left mouse button:

1. Entering a file (using the *File* menu on the Main Display)
2. Modifying a path, node, or reflector (using the *Static* or *Dynamic Parameter* displays). For each of these functions, a dialog box facilitates your selections.

Use the mouse (or the *Tab* key) to select parameters on the *Static* or *Dynamic Parameter* displays that you want to modify (see Figures 3-4 and 3-6). After you select the function, enter the new data from the keyboard.

Modify scroll bars by using any of the following techniques:

1. Dragging the marker with the mouse
2. Clicking in the area adjacent to the marker for coarse adjustments
3. Clicking the arrows at the end points for fine adjustments

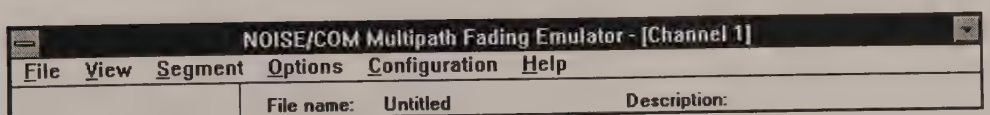
Alternatively, you may click on the numeric value above the scroll bar and then enter the value from the keyboard. Press *Enter* to activate your selection.

2. Operating the MP-2500 from the Keyboard

Menu Items

To access the menu commands, hold down the *Alt* key and press one of the following letters (see illustration below):

F	File Menu
V	View Menu
S	Segment Menu (Static Mode only)
N	Node Menu (Dynamic Mode only)
O	Options Menu
C	Configuration
H	Help Menu


NOISE/COM Multipath Fading Emulator - [Channel 1]
File View Segment Options Configuration Help
File name: Untitled
Description:

When the drop-down menu appears, use the *Arrow* keys to cursor through the list. Select a command by pressing *Enter*, or leave the menu by pressing *Esc*.

Controls

All controls in both parameter views and the dialog boxes can be accessed by *Tab*bing to the control or group of controls. There are six types of MP-2500 controls:

Radio Buttons - used to select a single option from a group. *Tab* to the group, then use the *Arrow* keys to change the selection. The *Continuous Run*, *Multiple Run*, and *Single Run* buttons are examples of radio buttons.

Push Buttons - used to initiate an action. *Tab* to the button, then press the *Space* bar to "push" it. The *Reset*, *Start*, and *Pause* buttons are examples of push buttons.

Combo Boxes - used to select a single option from a group. *Tab* to the box, then use the *Arrow* keys to cursor through the list. The *Time* and *Speed Scale* boxes in the *Static Parameter View* are examples of Combo Boxes.

Edit Boxes - used to enter numerical or character data. *Tab* to the box, then type in the data required. Press the *Enter* key to validate the data. The *Description* and *Center Frequency* boxes are examples of Edit Boxes.

Scroll Bars - used to increment a setting by a preset amount. *Tab* to the bar, then press the *Arrow* keys to increment or decrement the setting. The *Center Frequency* and *Output Power* bars are examples of Scroll Bars.

List Boxes - used to select one item from a list of items. *Tab* to the list, then use the *Arrow* keys to cursor through the list. Hold down the *Shift* key while pressing one of the following keys:

N	Node List (Dynamic Mode only)
R	Reflector List (Dynamic Mode only)
P	Path List (Static Mode only)

A dialog box for data entry will appear.

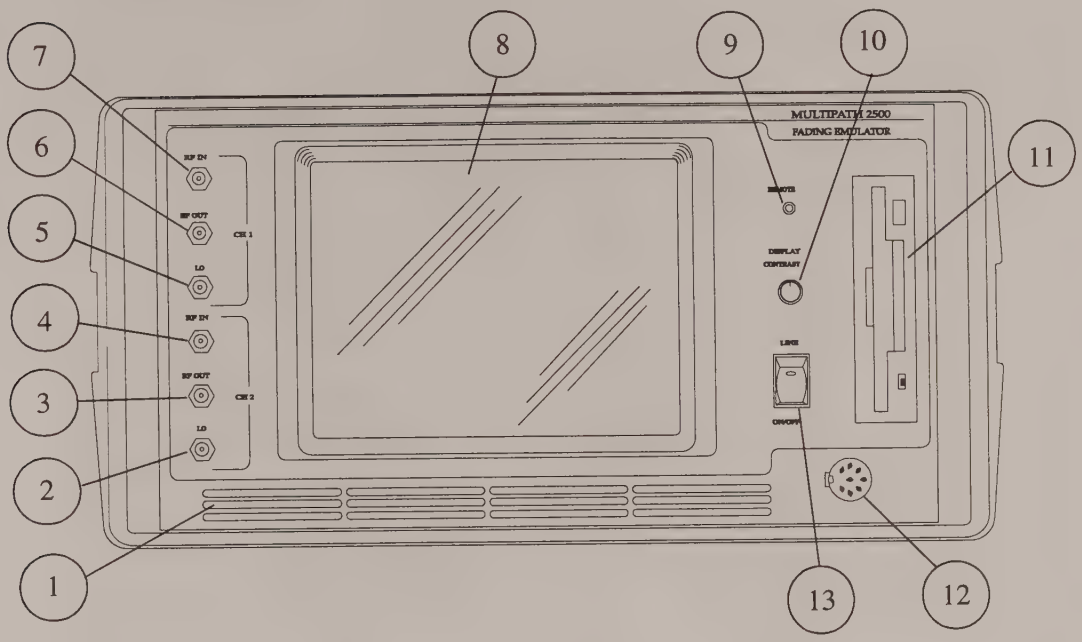
3. "Fast" Keys

Four function keys can be used for quick access to commonly used commands.

F1	Context Sensitive Help
F2	Same as pushing *Reset* button
F3	Same as pushing *Start* button
F4	Same as pushing *Pause* button

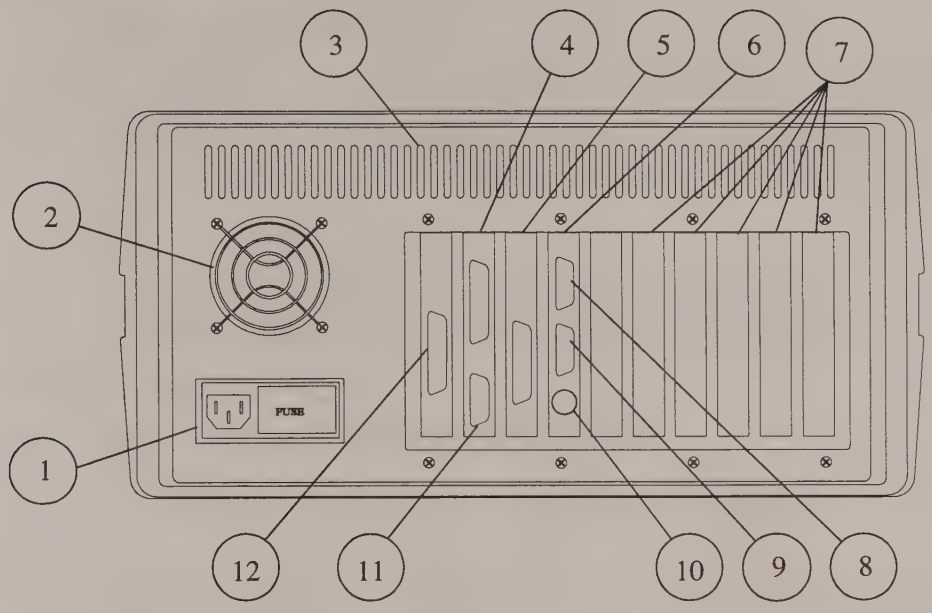
3.2 Controls, Indicators, and Connectors

Figures 3-2 illustrates the MP-2500 front panel of both the single and dual channel models. Figure 3-3 illustrates the MP-2500 rear panel.



Ref	Identification	Description
1	None	Air vent grille
2	Channel 2 LO	Input connector, SMA female
3	Channel 2 RF Out	Output connector, SMA female
4	Channel 2 RF In	Input connector, SMA female
5	Channel 1 LO	Input connector, SMA female
6	Channel 1 RF Out	Output connector, SMA female
7	Channel 1RF In	Input connector, SMA female
8	None	Flat panel color display
9	Remote	Control indicator LED
10	Display Contrast	Display contrast adjustment knob
11	None	3.5" floppy disk drive
12	None	Keyboard input/output connector
13	Line On/Off	AC power switch

Figure 3-2. MP-2500 Front Panel



Ref	Label	Description
1	Fuse	Combination power cord connector and fuse holder
2	None	Power supply ventilating fan
3	None	Air vent grille
4	None	VGA graphics driver assembly (Slot 2)
5	None	IEEE-488 bus interface (Slot 3)
6	None	486/33 single board computer (Slot 4)
7	None	Signal processing boards
8	None	Serial port
9	None	External mouse port
10	None	Auxiliary keyboard port
11	None	Auxiliary VGA port
12	None	Centronics parallel port

Figure 3-3. MP-2500 Rear Panel

3.3 Loading Files

3.3.1 *Open*ing Files

Opening a file causes a prestored data file to be loaded into the MP-2500 applications program, *mp2500.exe*. The parameter table for the selected mode will appear with the file parameters loaded. Figure 3-4 is a typical parameter table for the Static Mode. The file name and description appear at the top of the display.

3.3.2 *New* Files

Selecting a new file causes the MP-2500 to initialize to the default conditions. The file name will appear as *Untitled* and the file description block will be empty.

3.4 Saving Files

3.4.1 Saving a File Under a New File Name

You can type a file description directly in the description block on the parameter view before you save the file. A description is not required to save a file.

When you wish to save a file under a new name, use the *File, Save As* command. This will enable you to modify the name of the file before storing it on the hard drive.

3.4.2 Overwriting an Existing File (Save)

Using the *File, Save* command will store the file on the hard drive under the name that appears at the top of the parameter table display. The MP-2500 automatically appends an extension of *.sta* onto *Static* files and *.dyn* onto *Dynamic* files.

As with the *File, Save As* command, a description is not required to save a file.

3.5 Running Files

3.5.1 Starting a File

Once all parameters have been set to their desired values, you can run the file by pressing F3 or by clicking on the *Start* button, which appears on both the parameter view and the *Dynamic* simulation map view. The *Status* display will change from *READY* to *RUNNING* and the timers will increment as the simulation runs.

3.5.2 Pausing a File

You can pause a file during a program run by pressing F4 or by clicking on the *Pause* button. Click the *Start* button to resume the file.

3.5.3 Resetting a File

You can reset a file to its initial conditions by pressing F2 or by clicking the *Reset* button. After a file has been run, certain parameters cannot be modified until you press the *Reset* button.

3.6 Editing Files

You can edit MP-2500 files using any one (or a combination) of three monitor views:

- Static Parameter
- Dynamic Parameter
- Dynamic Map

3.6.1 Static Parameter View (See Figure 3-4)

This section will explain how to edit the emulator controls and use the menu functions when you are in the *Static Parameter* view.

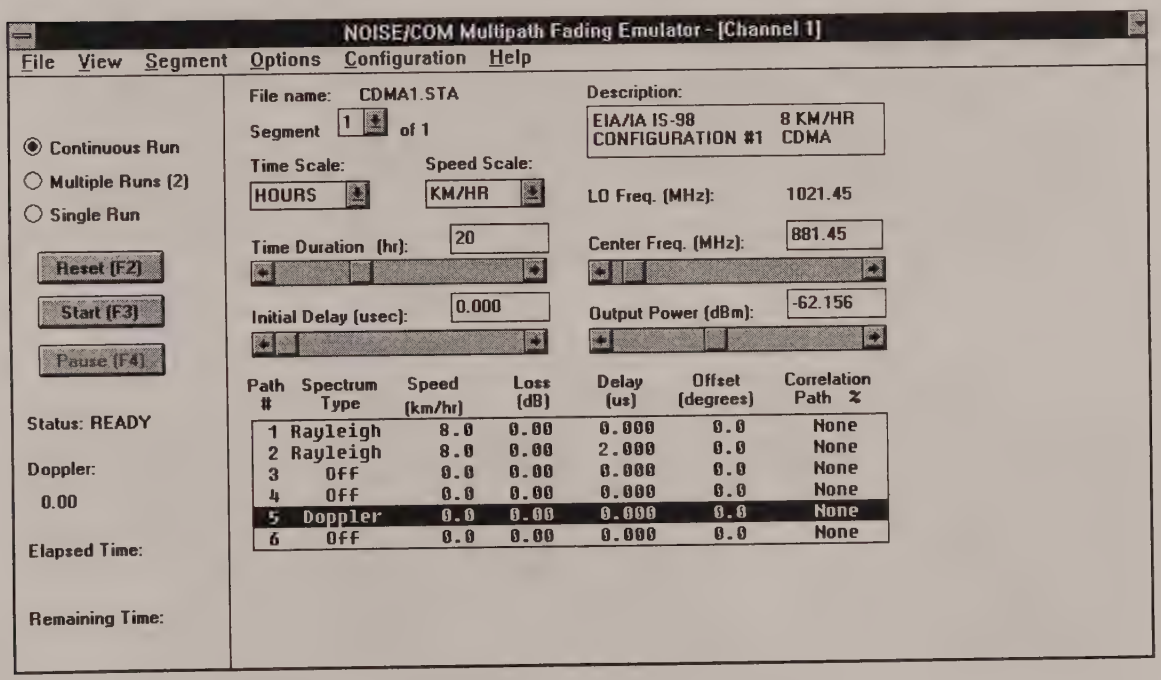
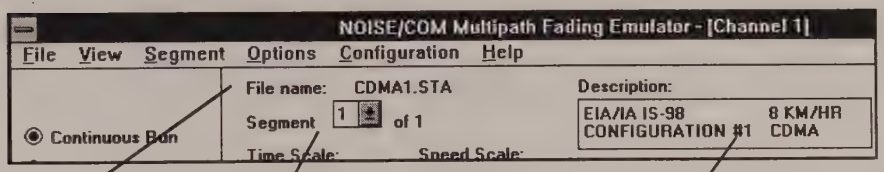

NOISE/COM Multipath Fading Emulator - [Channel 1]
File View Segment Options Configuration Help
Continuous Run
Multiple Runs (2)
Single Run
Reset (F2)
Start (F3)
Pause (F4)
Status: READY
Doppler:
0.00
Elapsed Time:
Remaining Time:
File name: CDMA1.STA
Segment 1 of 1
Description:
EIA/IA IS-98 8 KM/HR
CONFIGURATION #1 CDMA
Time Scale: HOURS
Speed Scale: KM/HR
LO Freq. (MHz): 1021.45
Time Duration (hr): 20
Center Freq. (MHz): 881.45
Initial Delay (usec): 0.000
Output Power (dBm): -62.156
Path # Spectrum Type Speed (km/hr) Loss (dB) Delay (us) Offset (degrees) Correlation Path
1 Rayleigh 8.0 0.00 0.000 0.0 None
2 Rayleigh 8.0 0.00 2.000 0.0 None
3 Off 0.0 0.00 0.000 0.0 None
4 Off 0.0 0.00 0.000 0.0 None
5 Doppler 0.0 0.00 0.000 0.0 None
6 Off 0.0 0.00 0.000 0.0 None

Figure 3-4. Typical Static Parameter View

3.6.1 Static Parameter View *(continued)*

1. Editing the Controls

The controls for the Static Parameter view operate as follows:



File Name

Displays the name of the file which is currently loaded into the MP-2500 application program (*mp2500.exe*). The file name is entered or modified using the *File, Save* and *File, Save As* commands.

Segment

Selects the segment which is currently being displayed. A simulation file can be subdivided into as many as eight sequential segments. Each segment contains the display parameters for a portion of the simulation. The segments sequence automatically while a file is running.

Description

Description of file which is currently loaded into *mp2500.exe*. Enter or modify a description by clicking on the block and typing the desired entry. A description is not required to run or save a file. The upper case letters N, R, and P cannot be used because they are reserved for controls. (See *3.1.2 Using the Mouse and Keyboard, 2. Operating the MP-2500 from the Keyboard, Controls.*)

Time Scale

Selects the units (HOURS, MINUTES, SECONDS) for the *Time Duration* parameter.

Speed Scale

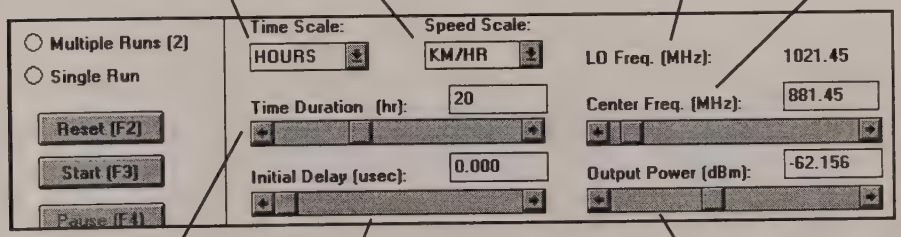
Selects the units (MILES/HR, KM/HR, FT/SEC, M/SEC) for the *Doppler* parameter. When the dialog box appears, select *Yes* to confirm that you wish to proceed. (See also *Doppler*).

LO Frequency

A prompt that indicates the required local oscillator frequency.

Center Frequency

Used to: (1) calculate the fading parameters; (2) control the output frequency of the synthesized local oscillator; and (3) control the tuned frequency of the YIG filter at the MP-2500 RF output.



Time Duration

Sets the length of time a file will run. A duration of 0 is not valid.

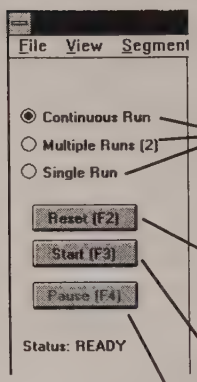
Initial Delay

Applies a fixed delay to all paths, which is in addition to any delay set in the path itself. Total delay for any path cannot exceed 216 microseconds.

Output Power

Sets the average RF power at the MP-2500 output by adjusting the RF attenuator.

3.6.1 Static Parameter View *(continued)*



Continuous/Multiple/Single Runs

Selects the number of times a file is run before halting. When *Multiple Runs* is selected, the number of runs is entered using a dialog box. When *Continuous Run* is selected, the file runs repeatedly for the time interval set by the *Time Duration* slide bar. The file continues to repeat until you stop it by pressing either the *Reset (F2)* button or the *Pause (F4)* button. The output is interrupted momentarily at the end of each run. If you wish to avoid this output interruption, set the *Time Duration* parameter to a value greater than the test duration.

Reset

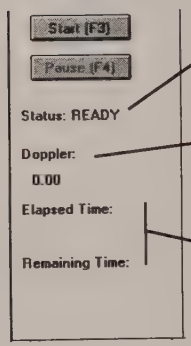
Initializes a file to its beginning after the file has run. Reset is required after running a file before certain parameters can be modified.

Start

Begins file execution. If pressed after *Pause,* execution begins at the point that the program was paused.

Pause

Halts execution of a file at its current state. Allows restarting the file without returning to the beginning.



Status

Indicates the run state of the current file: *READY, RUNNING, PAUSED, or DONE.*

Doppler

Indicates speed along the selected path.

Elapsed Time/Remaining Time

Real time counters which indicate the elapsed time and the time remaining for the current segment.

Path #	Spectrum Type	Speed (km/hr)	Loss (dB)	Delay (us)	Offset (degrees)	Correlation Path X
1	Off	0.000	0.00	0.000	0.0	None
2	Off	0.000	0.00	0.000	0.0	None
3	Off	0.000	0.00	0.000	0.0	None
4	Off	0.000	0.00	0.000	0.0	None
5	Off	0.000	0.00	0.000	0.0	None
6	Off	0.000	0.00	0.000	0.0	None

Path Table

Allows entry of conditions for each path. Modifications are made by double-clicking on the path (or by pressing *Shift-P*) to invoke the Change Path X Parameters dialog box (Figure 3-5).

3.6.1 Static Parameter View *(continued)*

Spectrum Type

Doppler, Rayleigh, Rician, Log-Normal, Suzuki, Nakagami, or *Off. Doppler* will apply a pure Doppler offset. The other selections will apply the indicated statistical distribution. Rician is available on Path 1 only as required by Rec 5.05 Annex 3 for GSM testing.

Speed

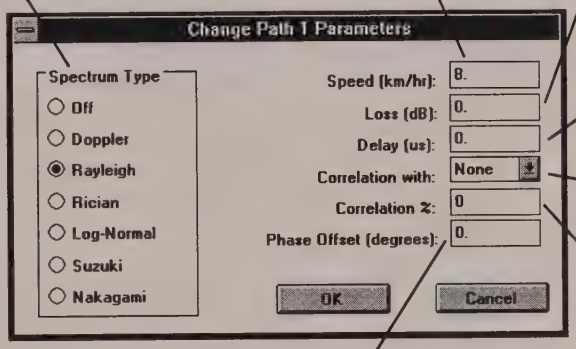
Sets the speed that is used during emulation. The Doppler shift is calculated from the speed and is displayed in the left column of the screen.

Loss

The path loss is entered via the keyboard.

Delay

The path delay is entered via the keyboard. Any delay value in the *Initial Delay* scroll bar will be added to this value.



Correlation with

Specifies the path that will be correlated with the selected path.

Phase Offset

Adds the specified phase shift to the path, relative to 0 degrees. NOTE: *Phase Offset* is not valid for *Speed* = 0.

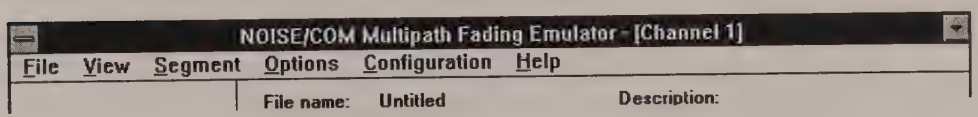
Correlation%

Selects the amount by which the paths will be correlated.

Figure 3-5. Change Path *X* Parameters Dialog Box

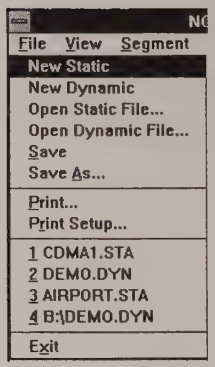
2. Using the Menu Functions

Six function menus appear across the top of the *Static View* parameter table, as illustrated below.


NOISE/COM Multipath Fading Emulator - [Channel 1]
File View Segment Options Configuration Help
File name: Untitled
Description:

The menu functions are described as follows:

3.6.1 Static Parameter View *(continued)*

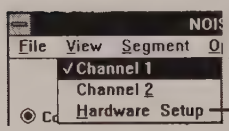


File

Menu contains the *New Static, New Dynamic, Open Static File, Open Dynamic File, Save, Save As, Print, and Print Setup* commands.

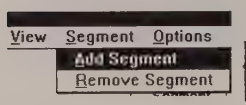
View

Selects the current display. Use the *View* commands to select among the following display views:



Channel 1 or Channel 2 (Parameter Tables). Displays current file settings in tabular form.

Hardware Setup. Displays the current hardware settings in a block diagram form. No modifications of the diagram can be made from this display.

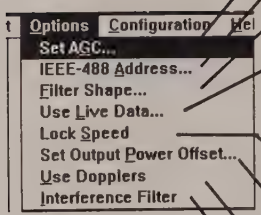


Segment

Enables you to *Add* or *Remove* segments.

Options

Provides the following controls:



Set AGC. Toggles between automatic gain control on and off.

IEEE-488 Address. Enables you to set the IEEE-488 address.

Filter Shape. Enables you to select the desired spectral distribution of the Gaussian noise sources. The currently selected shape is displayed.

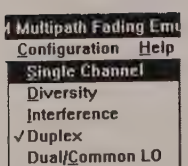
Use Live Data. Enables you to select between path values entered in the path table and values stored in a data file. This feature is useful for running data collected in the field. It can also be used to create time-varying parameters in the *Static* mode. The parameters are updated in increments of 100 msec when a "live data" file is used.

Lock Speed. When active, automatically changes all path speeds to the value entered in any modified path.

Set Output Power Offset. Enables you to offset the actual output power from the displayed value.

Use Dopplers. Toggles table entry between *Doppler* and *Speed.*

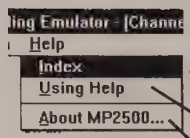
Interference Filter. Selects filter for adjacent channel interference test.



Configuration

Enables you to select among *Single, Diversity, Interference, Duplex,* and *Dual/Common LO. Single* configures the MP-2500 for single channel operation. *Diversity, Interference, Duplex,* and *Dual/Common LO* are dual channel configurations. *Section 6 Applications* provides guidance for selecting the appropriate configuration.

3.6.1 Static Parameter View *(continued)*



Help

Provides *Help* screens that instruct you on the use of the *mp2500.exe* application software. The *Help* menu contains the following information:

Index. An alphabetical index of the topics covered in the *Help* screens.

Using Help. Instructs you on how to navigate through the *Help* menus to find the desired topic.

About MP-2500. Lists the version of *mp2500.exe* that is loaded into your MP-2500.

3.6.2 Dynamic Parameter View (See Figure 3-6)

This section will explain how to edit the emulator controls and use the menu functions when you are in the Dynamic Parameter view.

NOISE/COM Multipath Fading Emulator - [Dynamic Parameter View]

File View Node Options Configuration Help

File name: Untitled.dyn Description:

LO Freq. (MHz): 940.00 / 940.00

◉ Continuous Run
○ Multiple Runs (2)
○ Single Run

Reset (F2)
Start (F3)
Pause (F4)

Status: READY
Vehicle Speed (km/hr):
(X,Y) Position (km):
Elapsed Time:
Remaining Time:

Node Number	Speed (km/hr)	X Position (km)	Y Position (km)
1	0.00	1.25	1.25
2	50.00	6.25	1.25

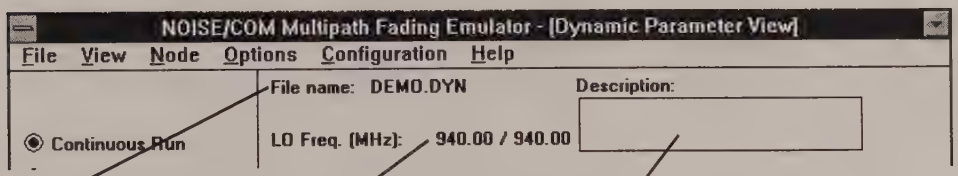
Transmitter Number	Center Freq. (MHz)	Output Atten. (dB)	X Position (km)	Y Position (km)
1	800.00	0.00	25.00	25.00
2	800.00	0.00	25.00	25.00

Reflector Number	Spectrum Type	Reflector Loss (dB)	X Position (km)	Y Position (km)
1	Rayleigh	3.00	8.25	18.00
2	Doppler	12.00	9.00	34.88
3	Rayleigh	0.00	21.75	35.37
4	Rayleigh	30.00	42.00	45.37
5	Off	30.00	24.63	6.13

Figure 3-6. Typical Dynamic Parameter View

3.6.2 Dynamic Parameter View *(continued)*

1. Editing the Controls


NOISE/COM Multipath Fading Emulator - [Dynamic Parameter View]
File View Node Options Configuration Help
File name: DEMO.DYN
Description:
Continuous Run
LO Freq. (MHz): 940.00 / 940.00

File Name

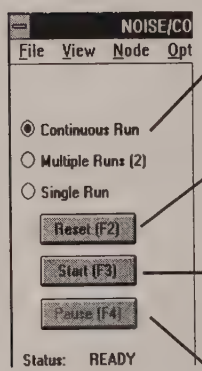
Displays the name of the file which is currently loaded into *mp2500.exe*. The file name is entered or modified using the *File, Save* and *Save As* commands.

LO Frequency

A prompt that indicates the required local oscillator frequencies for Channels 1 and 2.

Description

Description of the file that is currently loaded into *mp2500.exe*. The description is entered or modified by clicking on the block and typing the desired entry. The description is not required to run or save a file. Note that the upper case letters N, R, T, and P cannot be used because they are reserved for controls. (See *3.1.2 Using the Mouse and Keyboard, 2. Operating the MP-2500 from the Keyboard, Controls*.)



Continuous/Multiple/Single Runs

Selects the number of times a file is run before halting. When *Multiple Runs* is selected, the number of runs is entered using a dialog box.

Reset

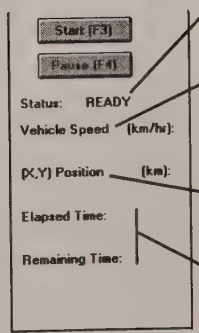
Initializes a file to its beginning after the file has run. Reset is required after running a file before certain parameters can be modified.

Start

Begins execution of a file. If pressed after *Pause*, execution begins at the point at which the program was paused.

Pause

Halts execution of a file at its current state. Enables you to restart the file without returning to the beginning.



Status

Indicates the run state of the current file: *READY, RUNNING, PAUSED, or DONE.*

Vehicle Speed

Indicates the current vehicle (mobile transceiver) speed while a file is running.

(X,Y) Position

Indicates the current vehicle (mobile transceiver) position while a file is running.

Elapsed Time/Remaining Time

Real time counters which indicate the elapsed time and remaining time for the current segment.

3.6.2 Dynamic Parameter View *(continued)*

Node Number	Speed (km/hr)	X Position (km)	Y Position (km)
1	30.00	0.03	0.03
2	50.00	0.13	0.02
3	100.00	0.20	0.52

Node Table

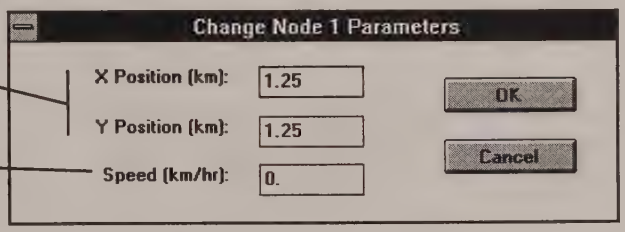
Enables you to enter the position of a node and the speed of the mobile transceiver at that node. You modify this data by double-clicking on the node (or by pressing *SHIFT-N*) to invoke the *Change Node X Parameters* dialog box (see below). Use the vertical scroll bar to view the rest of the data if more than three nodes are active.

X, Y Position

Enter the X and Y coordinates of the node.

Speed

Enter the node speed in the selected unit.



Station Number	Center Freq. (MHz)	Output Atten. (dB)	X Position (km)	Y Position (km)
1	800.00	0.00	0.50	0.50
2	800.00	0.00	0.90	0.90

Station Table

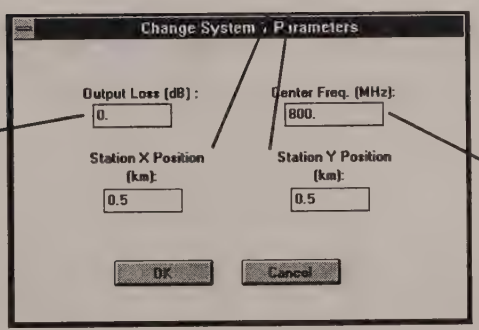
For dual channel configurations, enables you to enter the frequency, channel attenuation, and position of two base stations (non-mobile transceivers). You modify this data by double-clicking on the station number or by pressing *SHIFT-T* to invoke the *Change System X Parameter*s dialog box (below).

X, Y Position

Enter the X and Y coordinates of the base station.

Output Loss

Enter the attenuation value that is needed to establish the desired output power level.



Center Frequency

Enter the center frequency of the station transmitter in MHz.

3.6.2 Dynamic Parameter View *(continued)*

Reflector Number	Spectrum Type	Reflector Loss (dB)	X Position (km)	Y Position (km)
1	Rayleigh	0.00	0.40	0.87
2	Rician	0.00	0.35	0.18
3	Log-Norm	0.00	0.81	0.72
4	Doppler	0.00	0.58	0.24
5	Suzuki	0.00	0.33	0.75

Reflector Table

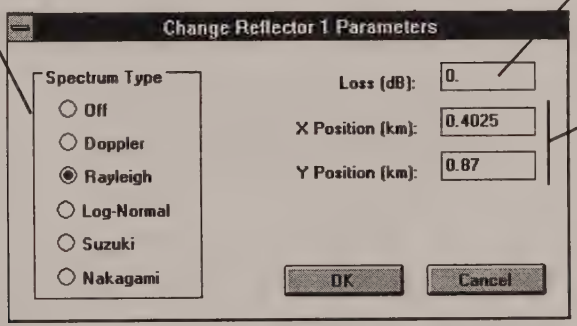
Enables you to enter the conditions for each reflector. Reflectors are modified by double-clicking on the reflector (or by pressing *SHIFT-R*) to invoke the *Change Reflector X Parameters* dialog box. The reflector conditions are also updated if a reflector is modified from the Map View.

Spectrum Type

Doppler, Rayleigh, Log-Normal, Suzuki, Nakagami, or *Off. Doppler* will apply a pure Doppler offset. The other selections will apply the indicated statistical distribution.

Reflector Loss

Enter the loss (in dB) of the reflector due to its reflection coefficient. The path length loss relative to the direct path is calculated automatically by the MP-2500.

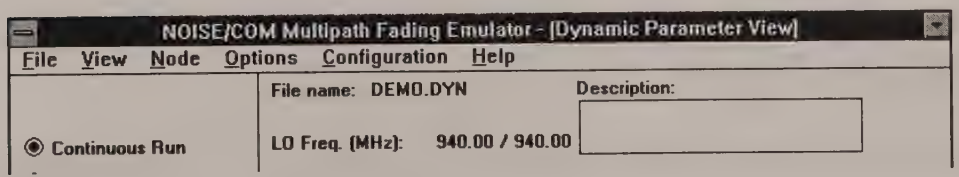


X, Y Position

Enter the X and Y coordinates of the reflector.

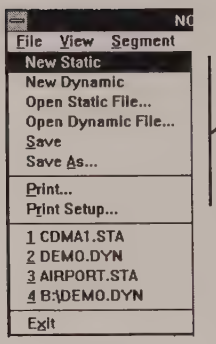
2. Using the Menu Functions

The six function menus appear across the top of the *Dynamic View* parameter table.


NOISE/COM Multipath Fading Emulator - [Dynamic Parameter View]
File View Node Options Configuration Help
File name: DEMO.DYN
Description:
Continuous Run
LO Freq. (MHz): 940.00 / 940.00

The menu functions are described as follows:

3.6.2 Dynamic Parameter View *(continued)*

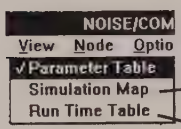


File

Menu contains the *New Static, New Dynamic, Open Static File, Open Dynamic File, Save, Save As, Print, and Print Setup* commands.

View

Selects the current display. Use the *View* commands to select among the following display views:

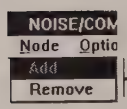


Parameter Table. Displays current file settings in tabular form.

Simulation Map. Graphically displays the positions of the receiver, reflectors, base stations, and shadow.

Run-time Table. When active, overlays the simulation map with real-time path parameters, as the file is running.

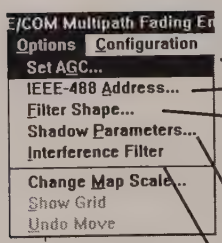
Node



Enables you to *Add* or *Remove* nodes. A node must be activated by clicking on it before it can be removed. When a node is removed, the remaining nodes are renumbered sequentially.

Options

Provides the following controls:



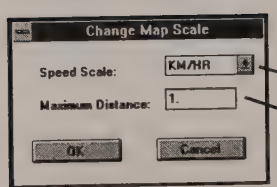
Set AGC. Toggles between automatic gain control on and off.

IEEE-488 Address. Enables you to set the IEEE-488 address.

Filter Shape. Enables you to select the desired spectral distribution for the Gaussian noise source. The currently selected distribution is displayed above a drop-down menu labeled *Filter Selections* (see Figure 3-7). Click on the arrow adjacent to the *Filter Selections* drop-down menu to view the selection of filter files available. Highlight the filter you wish to use and press the *Select* button. The default filter file, *shape1.flt*, generates the spreading associated with omnidirection antennas on the mobile and the base station. The reflector antenna patterns are uniformly distributed per international specifications (e.g., GSM, TDMA, CDMA, and CDPD).

Shadow Parameters. Invokes the *Change Shadow Parameters* dialog box (Figure 3-8) that enables and disables the shadow and sets the shadow size, position, and loss.

Change Map Scale. Invokes the *Change Map Scale* dialog box that provides the following functions:



Speed Scale	Set units of speed and distance.
Maximum Distance	Scales the simulation map. For example, a setting of 1 (km) will cause the map to show a 1 km x 1 km block.

3.6.2 Dynamic Parameter View *(continued)*

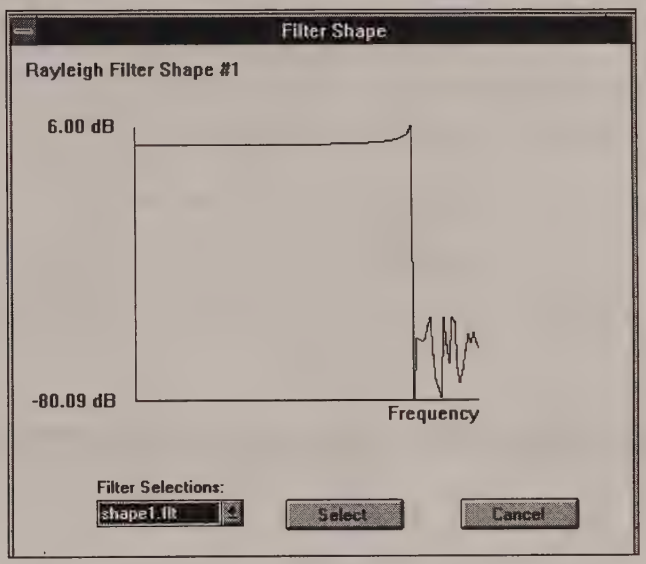


Figure 3-7. Filter Shape Selection Display

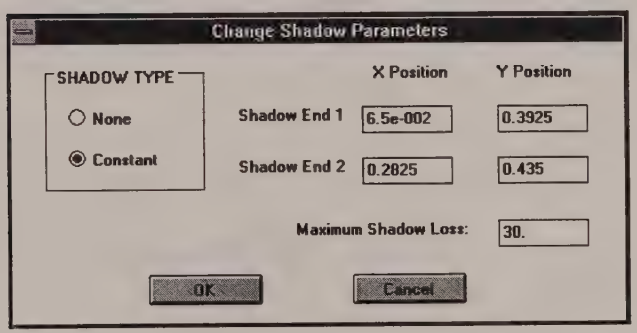
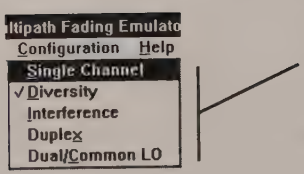


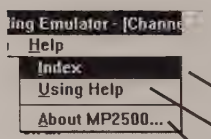
Figure 3-8. Change Shadow Parameters Dialog Box



Configuration

Enables you to select among *Single Channel, Diversity, Interference, Duplex,* and *Dual/Common LO. Single Channel* configures the MP-2500 for single channel operation. *Diversity, Interference, Duplex,* and *Dual/Common LO* are dual channel configurations. *Section 6 Applications* provides guidance for selecting the appropriate configuration.

3.6.2 Dynamic Parameter View *(continued)*



Help

Provides *Help* screens that instruct you on the use of the *mp2500.exe* application software. The *Help* menu contains the following:

Index. An alphabetical index of the topics covered in the *Help* screens.

Using Help. Instructs you on how to navigate through the *Help* menus to find the desired topic.

About MP-2500. Lists the version of *mp2500.exe* that is loaded into your MP-2500.

3.6.3 Dynamic Simulation Map View (See Figure 3-9)

This section will explain how to edit the emulator controls, use the menu functions, and edit the map when you are in the Dynamic Simulation Map view.

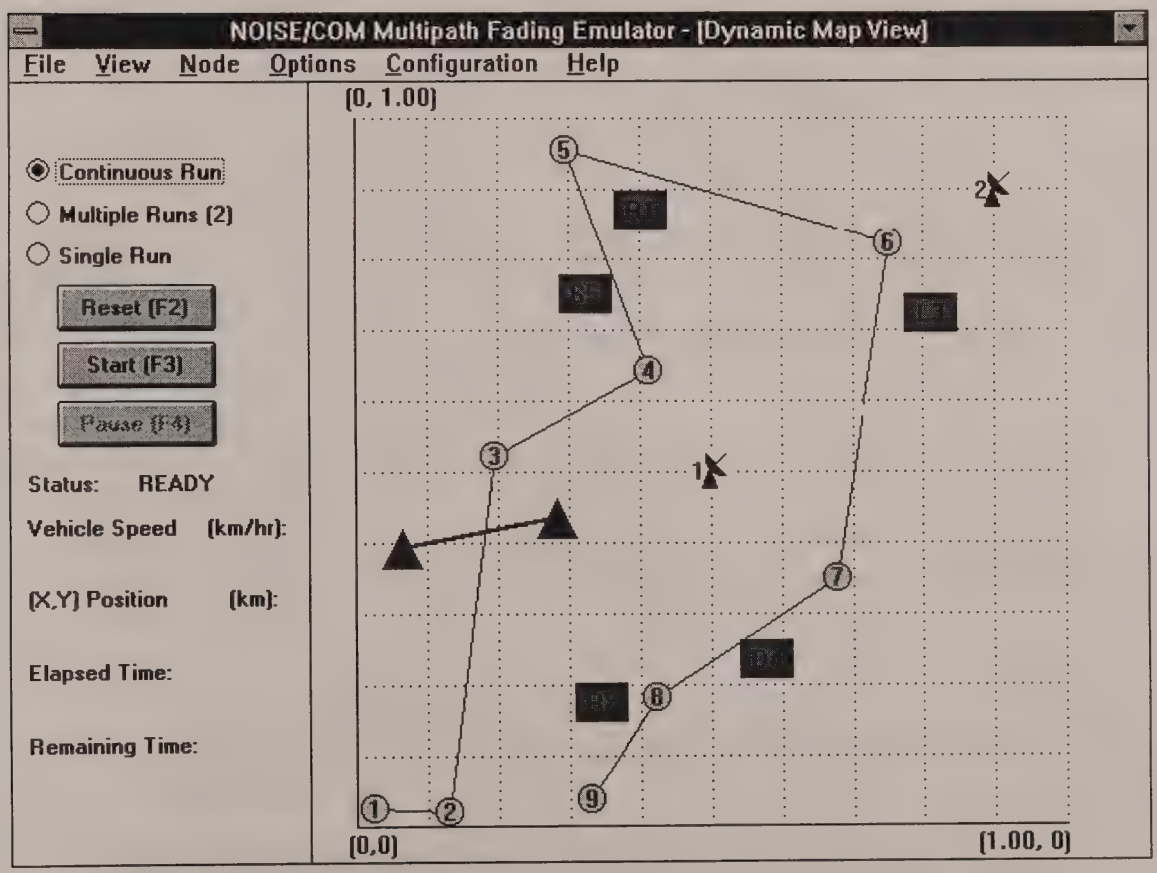
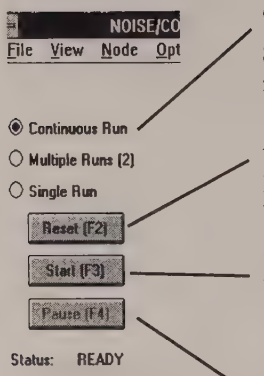


Figure 3-9. Typical Dynamic Simulation Map View

3.6.2 Dynamic Parameter View *(continued)*

1. Editing the Controls



Continuous/Multiple/Single Runs

Selects the number of times a file is run before halting. When *Multiple Runs* is selected, the number of runs is entered using a dialog box.

Reset

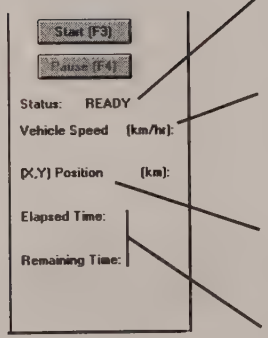
Initializes a file to its beginning after the file has run. Reset is required after running a file before certain parameters can be modified.

Start

Begins execution of a file. If pressed after *Pause,* execution begins at the point at which the program was paused.

Pause

Halts execution of a file at its current state. Enables you to restart the file without returning to the beginning.



Status

Indicates the run state of the current file: *READY, RUNNING, PAUSED, or DONE.*

Vehicle Speed

Indicates the current vehicle (mobile transceiver) speed while a file is running.

(X,Y) Position

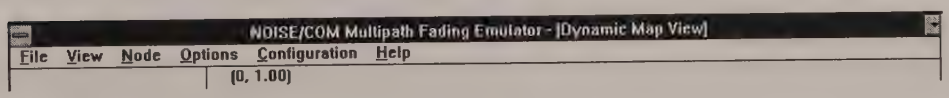
Indicates the current vehicle (mobile transceiver) position while a file is running.

Elapsed Time/Remaining Time

Real time counters which indicate the elapsed time and remaining time for the current segment.

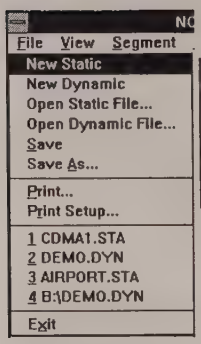
2. Using the Menu Functions

Six function menus appear across the top of the *Dynamic Simulation Map* view, as shown below.



The menu functions are described as follows:

3.6.3 Dynamic Simulation Map View *(continued)*

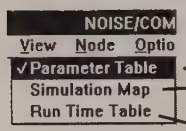


File

Menu contains the *New Static, New Dynamic, Open Static File, Open Dynamic File, Save, Save As, Print, and Print Setup* commands.

View

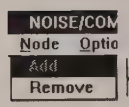
Selects the current display. Use the *View* commands to select among the following display views:



Parameter Table. Displays current file settings in tabular form.

Simulation Map. Graphically displays the positions of the receiver, reflectors, base stations, and shadow.

Run-time Table. When active, overlays the simulation map with real-time path parameters, as the file is running.

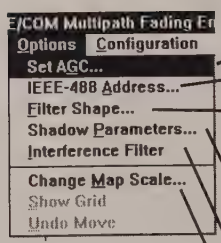


Node

Enables you to *Add* or *Remove* nodes. A node must be activated by clicking on it before it can be removed. When a node is removed, the remaining nodes are renumbered sequentially.

Options

Provides the following controls:



Set AGC. Toggles between automatic gain control on and off.

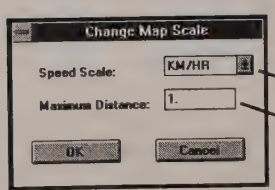
IEEE-488 Address. Enables you to set the IEEE-488 address.

Filter Shape. Enables you to select the desired spectral distribution for the Gaussian noise source. The currently selected distribution is displayed above a drop-down menu labeled *Filter Selections* (see Figure 3-7). Click on the arrow adjacent to the *Filter Selections* drop-down menu to view the selection of filter files available. Highlight the filter you wish to use and press the *Select* button. The default filter file, *shape1.flt*, generates the spreading associated with omnidirection antennas on the mobile and the base station. The reflector antenna patterns are uniformly distributed per international specifications (e.g., GSM, TDMA, CDMA, and CDPD).

Shadow Parameters. Invokes the *Change Shadow Parameters* dialog box (Figure 3-8) that enables and disables the shadow and sets the shadow size, position, and loss.

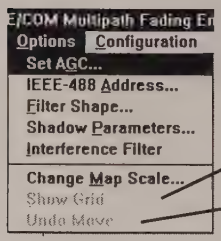
Interference Filter. Selects filter for adjacent channel intereference test.

Change Map Scale. Invokes the *Change Map Scale* dialog box that provides the following functions:



Speed Scale	Set units of speed and distance.
Maximum Distance	Scales the simulation map. For example, a setting of 1 (km) will cause the map to show a 1 km x 1 km block.

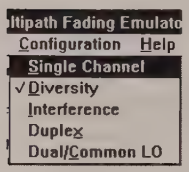
3.6.3 Dynamic Simulation Map View *(continued)*



Options (continued)

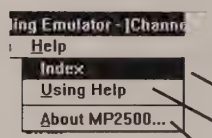
Show (Hide) Grid. Displays (or removes) vertical and horizontal grid lines on the map.

Undo Move. Returns the most recently moved node to its original position.



Configuration

Enables you to select among *Single Channel, Diversity, Interference, Duplex,* and *Dual/Common LO. Single Channel* configures the MP-2500 for single channel operation. *Diversity, Interference, Duplex,* and *Dual/Common LO* are dual channel configurations. *Section 6 Applications* provides guidance for selecting the appropriate configuration.



Help

Provides *Help* screens that instruct you on the use of the *mp2500.exe* application software. The *Help* menu contains the following information:

Index. An alphabetical index of the topics covered in the *Help* screens.

Using Help. Instructs you on how to navigate through the *Help* menus to find the desired topic.

About MP-2500. Lists the version of *mp2500.exe* that is loaded into your MP-2500.

3. Editing the Map

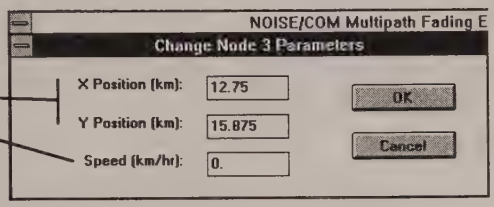
You can modify all icons on the map by double-clicking on the icon, invoking a dialog box. The position of icons can be modified by dragging them with the left mouse button held down. The *Current Position* field, which is located in the upper right-hand corner of the display, indicates the *x* and *y* coordinates of the active icon.

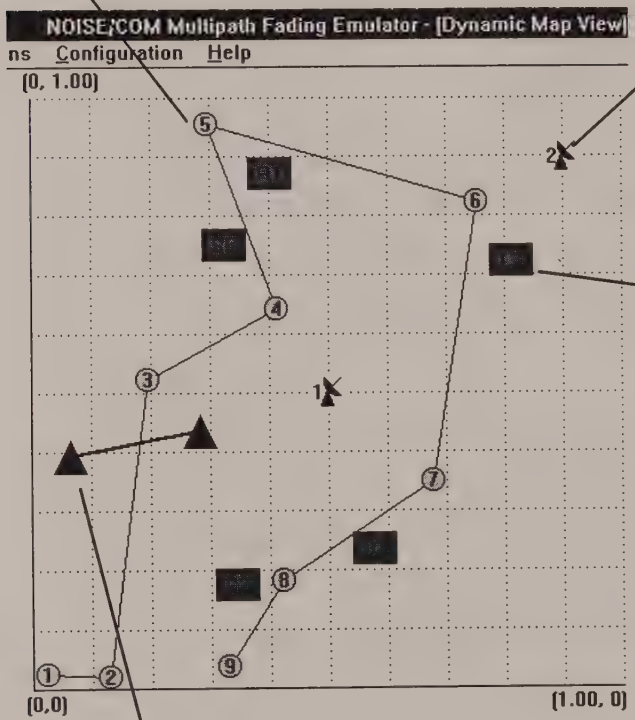
3.6.3 Dynamic Simulation Map View *(continued)*

Nodes

If less than nine nodes are active, you can *Add* a node by double-clicking in an empty area of the map. Double-clicking on an existing node will invoke the *Change Node X Parameters* dialog box, enabling you to enter the node position and the vehicle speed at that position.

You can *Remove* a node by clicking on the icon to active it (the background color of the activated node changes to black) and then using the *Remove* command from the *Node* menu





Base Stations

You can modify base station positions by double-clicking on the icon to invoke a dialog box, or by dragging the icon with the left mouse button held down.

Reflectors

You can modify reflectors by double-clicking on the icon, invoking a dialog box. An enabled reflector appears on the map with a solid perimeter and dark interior. A disabled reflector has a dashed perimeter line.

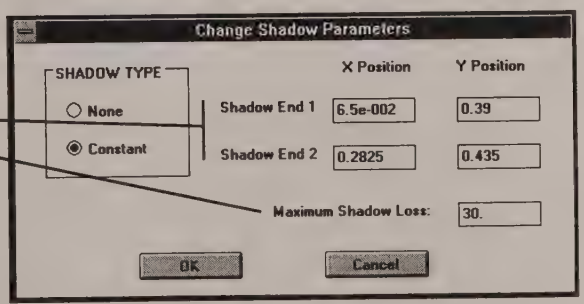
If the reflector's spectrum type is Doppler, it will be labeled with a *D*, followed by the reflector number. If the reflector is a Rayleigh type, the label will be *R*. You can move reflectors on the map by dragging them with the left mouse button held down.

Shadowing

You can modify the shadowing by double clicking on the end points of the line segment icon, invoking the *Change Shadow Parameters* dialog box. Use the dialog box to set the end points of the line segment and the amount of loss in the shadow.

The end points can also be moved by dragging them with the mouse.

Shadowing occurs when the base station-to-mobile path is fully or partially blocked. When the shadow line is between the base station and the mobile, the line-of-sight signal is attenuated.



3.7 Dual Channel Operation

File editing in the dual channel application is identical to file editing in the single channel application, with the following exceptions:

3.7.1 Static Parameter View

View Selects the current display. Use the *View* commands to move between the Channel 1and Channel 2 parameter tables and the Hardware Setup display.

Channel 1. Displays the parameter table for Channel 1.

Channel 2. Displays the parameter table for Channel 2.

Hardware Setup. Displays the current hardware settings in a block diagram form. No modifications of the diagram can be made from this display.

3.7.2 Dynamic Parameter View

Base Station Table Two base stations are available.

3.7.3 Dynamic Simulation Map View

The parameters for the second base station can be established by double clicking on the icon.

3.7.4 Operation

Step 1. Select *View, Channel 1* and establish the parameters for Channel 1.

Step 2. Select *View, Channel 2* and establish the parameters for Channel 2.

Step 3. Select *View, Channel 1* and press F3 or use the mouse to press the *Start* button.

Step 4. Select *View, Channel 2* and press F3 or use the mouse to press the *Start* button.

Section 4. Equipment Description

4.1 Block Diagram Description

Figure 4-1 is the functional block diagram of the MP-2500.

The RF input signal is downconverted by the external local oscillator, digitized, and applied to the digital signal processing (DSP) assembly. Up to six paths may be controlled by each of the two signal processors (DSP #1 and DSP #2). Each processed signal is converted to analog and upconverted. A YIG tracking filter in each channel provides a spurious-free RF output.

Automatic signal routing enables you to configure the MP-2500 to meet a variety of test requirements. The MP-2500 contains two independent channels with up to six paths each for duplex operation. Switch S1 enables you to route one RF input signal to both channels. In this configuration, the MP-2500 can provide up to 12 paths on a single channel and support diversity testing. Switch S2 enables you to combine internally the outputs of the two channels to support:

- single channel operation with 12 paths
- interference testing (C/I), as required for CDMA and GSM standards

Switch S3 enables you to apply separate LOs to each channel to support duplex operation. Alternatively, you can apply one LO input to both channels.

4.2 Functional Description

4.2.1 Down Converter and Demodulator Assembly

Figure 4-2 is the functional block diagram of the frequency converter assembly.

Input signals are applied to the AGC, which operates over an input power range from -10 dBm to +20 dBm. A fast attack detector in the AGC circuit accommodates pulsed and TDMA signals. The AGC can be disabled using computer commands. When the AGC is deactivated, the optimum input power for maximum SNR performance is approximately -10 dBm. The external local oscillator (LO) is used to down convert the RF input to 140 MHz. The 140 MHz signal is applied to an I/Q demodulator having an LO frequency of 144.5 MHz. The I and Q signals are filtered and digitized using two 12-bit analog-to-digital converters (ADCs) running at 18.518 MHz. The ADC output signals are applied to the DSP Assembly.

4.2.2 DSP Assembly

Figure 4-3 is the functional block diagram of the DSP Assembly.

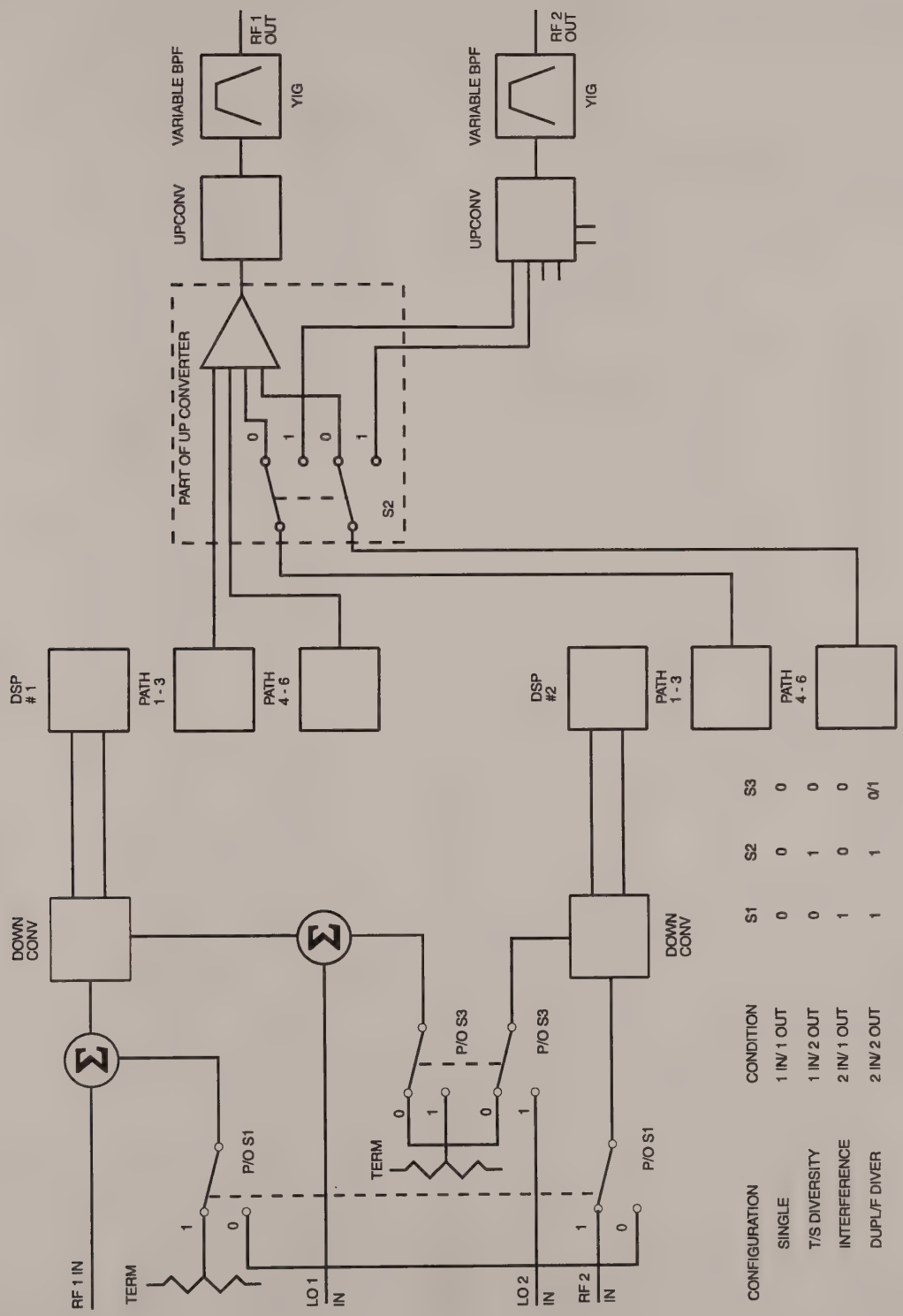


Figure 4-1. MP-2500 Functional Block Diagram

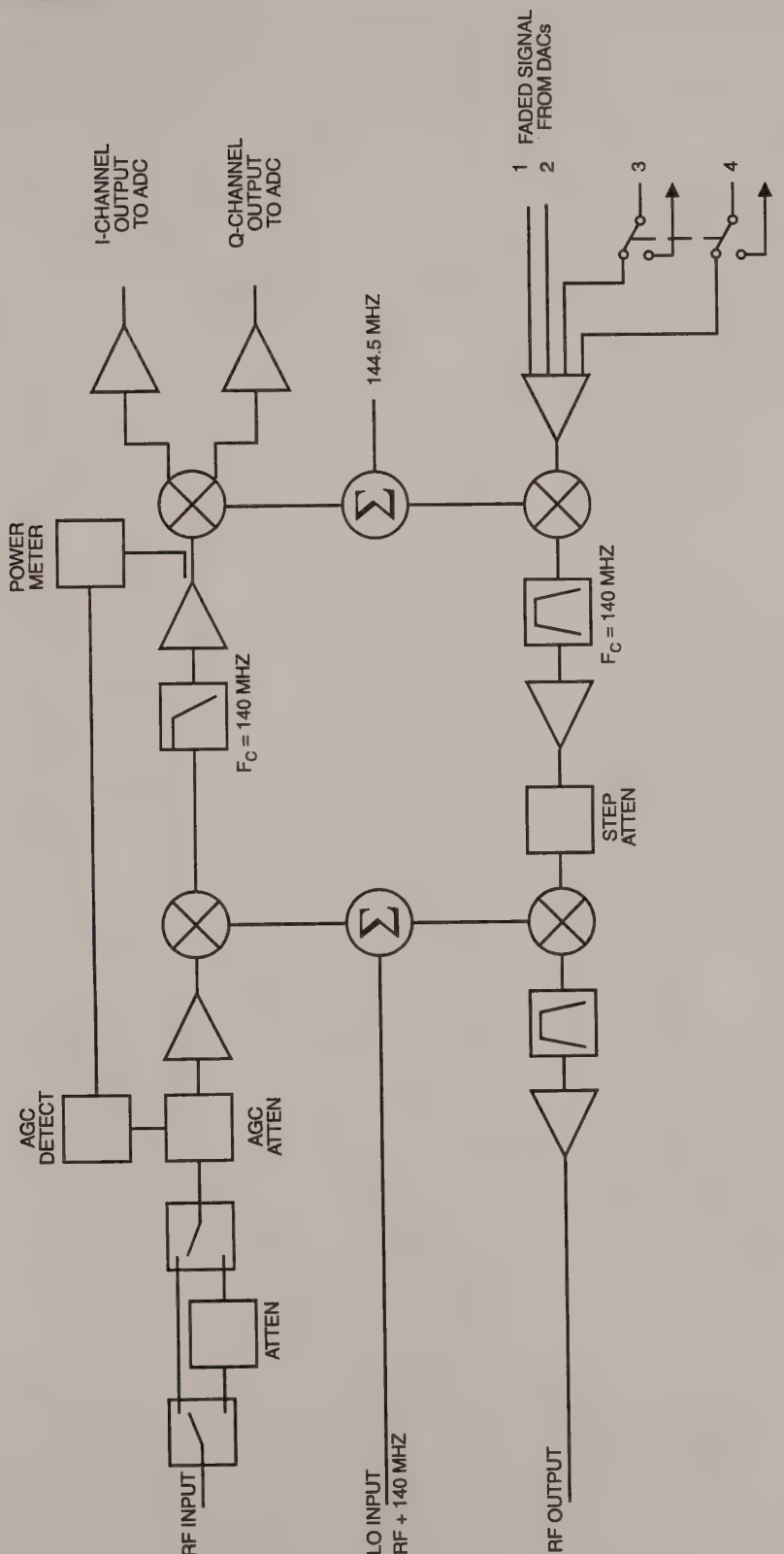


Figure 4-2. Frequency Converter Functional Block Diagram

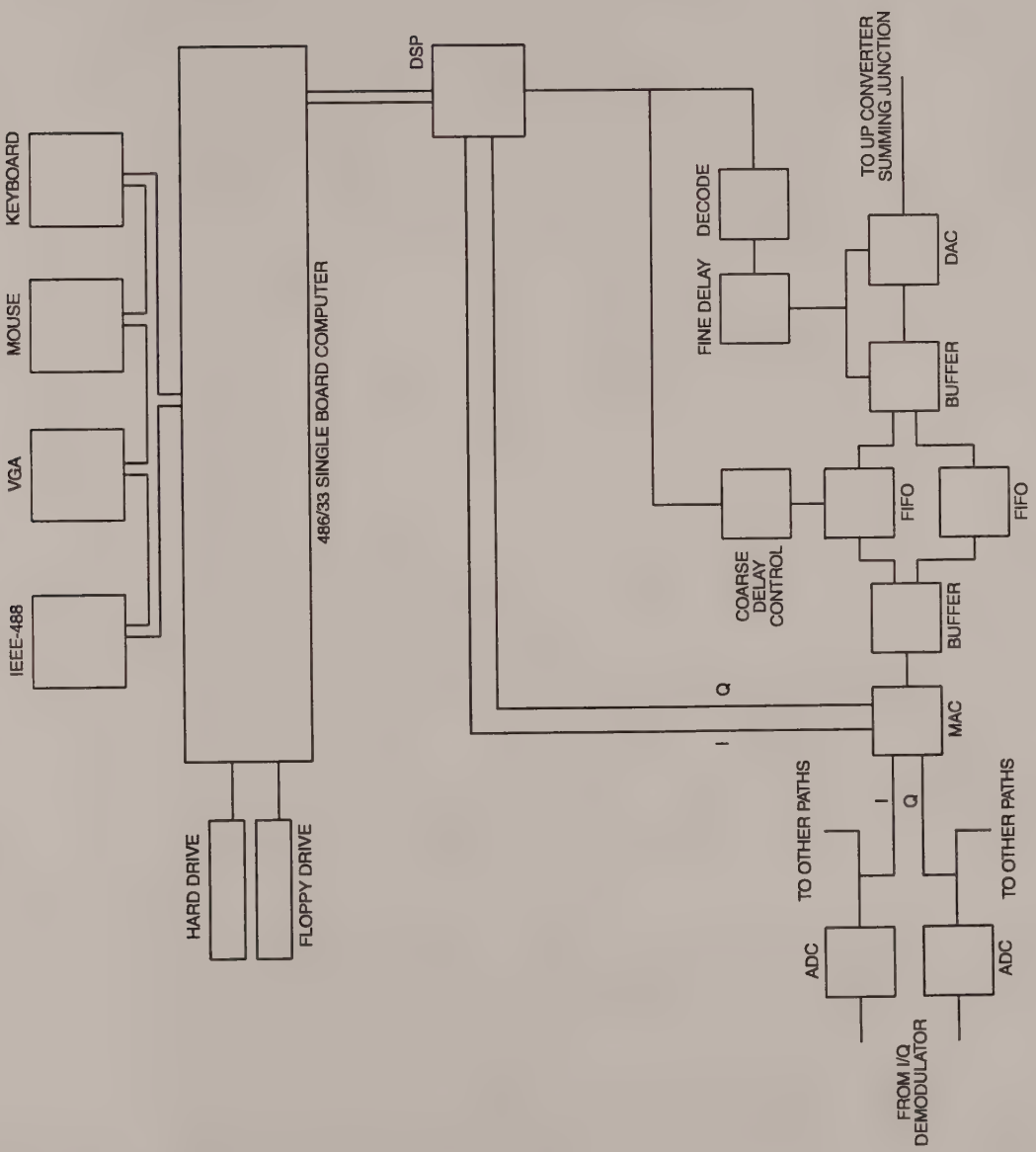


Figure 4-3. Digital Signal Processor Assembly Functional Block Diagram

The ADC I and Q channel outputs are applied to each of the equipped signal paths. Three paths are contained on each path assembly. Up to four path assemblies may be installed in the MP-2500.

The ADCs generate a 12-bit wide data stream which is bused to each signal path. In each path the data is applied to a multiply/accumulator (MAC). The MAC generates the Rayleigh distribution by multiplying the *I* sample by one Gaussian noise source and the *Q* sample by another uncorrelated Gaussian source. Signal amplitude is controlled by scaling the noise source output levels. The two products are summed and applied to the coarse delay circuitry, which is based on a first-in, first-out (FIFO) memory. The memory is clocked every 54 *nsec*, which establishes the coarse delay resolution. The depth of the memory is 4000 words, establishing the maximum delay of 216 μ*s*. Coarse delay is implemented by "holding off" the FIFO *write* strobe relative to the FIFO *read* strobe.

A fine delay circuit achieves the final delay resolution of 1 *nsec*. This circuit interpolates between the 54 *nsec* steps of the coarse delay. The output is a strobe which is applied to a digital-to-analog converter (DAC).

The outputs of all the DACs are summed to generate the faded signal.

4.2.3 Up Converter

The combined output from the DACs is upconverted to 140 MHz and filtered by a nondispersive SAW filter with very high selectivity. The up converter uses the same LOs as the down converter in order to cancel frequency drift associated with the LOs. The SAW filter establishes the bandwidth of the instrument, which is approximately 6 MHz at the 3-dB points. This bandwidth has been selected to accommodate CDMA, TDMA, HDTV, PCS, and most other communication formats. The signal power of the 140 MHz IF is set using a 63 dB step attenuator with 0.5 dB resolution. The 140 MHz IF signal is up converted to the original input frequency. The output signal power ranges between -19 dBm and -100 dBm, depending on the hardware configuration and attenuator settings.

4.2.4 Computer

The 486DX/33 computer is a single board computer which mates to the passive Industry Standard Architecture (ISA) motherboard. It has two serial ports and a parallel port. One serial port is used for the mouse. All three ports are available on the back panel.

A video graphics adaptor (VGA) driver board can simultaneously drive an external VGA display and the liquid crystal display (LCD) color display mounted on the front panel.

The computer includes an IEEE-488.2 interface, which is manufactured by the National Instruments Corporation (NIC). The interface includes hardware, software drivers, and the configuration and debug files. The NIC documentation for the interface is provided with the MP-2500.

A detachable keyboard is incorporated into the front panel cover. The mouse connects to a serial port on the rear panel.

4.2.5 Software

The MP-2500 is a turnkey instrument and includes the following preinstalled software:

1. DOS 5.0 (does not include all utilities which are typically included in a DOS package).
2. Microsoft Windows 3.1
3. The MP-2500 application program
4. Files for performing CDMA, GSM, DCS, and PCS testing.

The computer's *autoexec.bat* file and the Windows *Startup* file are configured such that the instrument will automatically execute *mp2500.exe* when the MP-2500 is turned on.

The configuration of the application program is determined by the *Command* line in the Program Item Properties for the MP-2500 application. To modify the *Command* line, proceed as follows:

1. Exit the MP-2500 application program.
2. Select *Properties* under the *File* menu in the Program Manager.
3. Tab to the *Command* line.

The Command line indicates the drive, directory, file name, and options that will be executed when Windows is initialized. The options that appear after the file name are as follows:

-pn sets the number of paths to be displayed on the parameter table in Channel 1. Default is 6.

-qn sets the number of paths to be displayed on the parameter table in Channel 2. Default is 6 for dual channel, 12 for single channel.

-a340 sets the Channel 1 ISA address to 340.

-b350 sets the Channel 2 ISA address to 350.

-u enables debug capability. (For factory use only.)

-h enables file editing while running on a PC.

-yn sets the lower center frequency limit on the graphic display; n is the frequency in MHz.

-xn sets the upper center frequency limit on the graphics display; n is the frequency in MHz.

4.3 Digital Signal Processing

All signal processing is accomplished digitally with 12-bit data representation. This provides very consistent and drift-free results not achievable using analog implementation.

The digital signal processor (DSP) performs the following tasks:

- **Communicates with the 486/33 computer via the ISA bus**
- **Generates the Gaussian noise distribution.** The Gaussian noise is generated by summing numerous uniform probability distributions.
- **Shapes the noise via a finite impulse response (FIR) filter.** The noise spectrum is shaped by a 256-tap FIR filter (implemented in software). Similarly, the noise amplitude is scaled and applied to the MAC. The DSP must perform these computations as many as 12 times, since two noise sources are required per path.
- **Generates sine/cosine waveforms for those paths which are selected for Doppler, rather than statistical fading.** The sine/cosine waveforms are generated using a phase accumulator. Scaling is performed similarly as with noise.
- **Scales the amplitude of the noise or sine wave**, ultimately scaling the signal level via the multiplication process.
- **Performs correlation between paths when required.** Paths are correlated by summing a portion of the noise sources from one path with the signal in the second path. The amount of the noise source which is summed with the correlated path determines the percentage of correlation between the paths. A path can be correlated with any other path.
- **Controls the path hardware.** The DSP also controls the path processing hardware. Settings for delay, path OFF, and certain timing signals are generated.

4.4 Physical Description

Figure 4-4 illustrates the interior components of the MP-2500. Table 4-1 identifies and describes the major assemblies and components. Figure 4-5 is a routing diagram of the interior RF cabling.

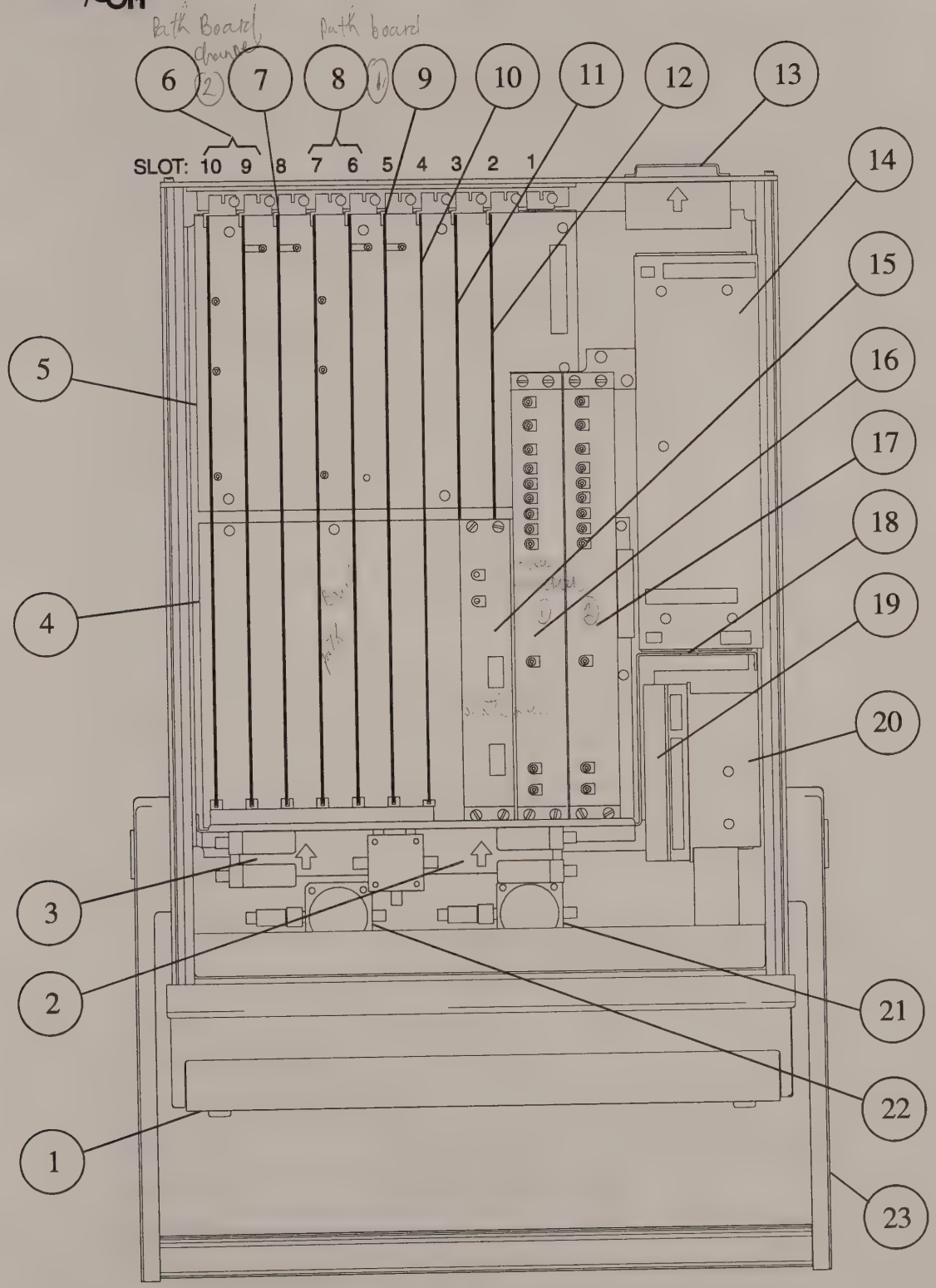


Figure 4-4. MP-2500 Interior Top View

Table 4-1: MP-2500 Assemblies and Components

Ref	Name	Description
1	Flip-down front cover	Contains integrated 88-key keyboard and pointing device, connected to the main chassis through a 5-pin DIN connector.
2, 3	Cooling fan	Dual fans draw air across internal components.
4	Proprietary backplane	Data bus between circuit cards. Distributes D.C. power to analog circuits.
5	ISA backplane	ISA signal bus. Distributes D.C. power to digital circuits.
6	Path boards (1 min.; 2 max.)	3 paths on each board.
7	DSP 2	
8	Path boards (1 min.; 2 max.)	3 paths on each board.
9	DSP 1	
10	Single board computer	486DX/33 self-contained computer.
11	IEEE-488 interface	NIC model PCIIA for GPIB instrument control.
12	VGA driver assembly	Zero wait-state VGA driver with 9-pin D connector for external VGA display.
13	Power supply cooling fan	
14	Switching power supply	300-watt power supply and filter board. Provides surge-free voltages to analog circuits.
15	Synthesizer	
16	Frequency Converter 1	
17	Frequency Converter 2	
18	EMI shield	Chassis conforms to EN55011, Group 1, Class A
19	Hard drive	420 Mbyte capacity; IDE.
20	Floppy disk drive	3.5" high density.
21, 22	Tunable bandpass filter	
23	Carrying handle	

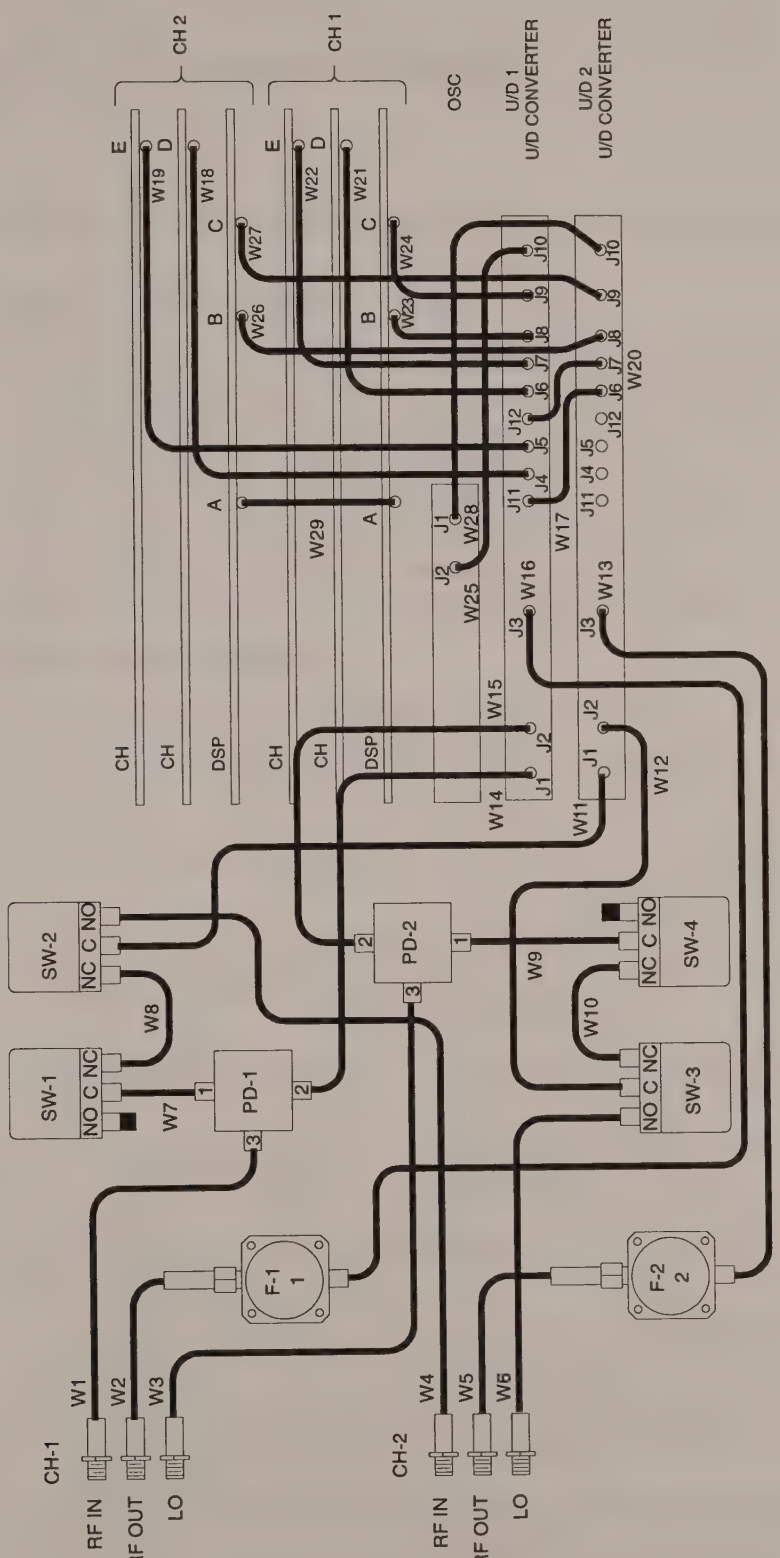


Figure 4-5. RF Cabling Diagram

Section 5. Remote Control

5.1 IEEE-488 Bus Description

Remote control of the MP-2500 is accomplished using an IEEE-488 bus interface. The IEEE-488 bus uses 16 lines for transfer of data and commands to as many as 15 instruments. Figure 5-1 illustrates the bus interconnect structure. The instruments on the bus are connected in parallel. Lines DIO 1 through 8 transfer information in a byte-serial, bit-parallel format. The remaining lines are used for timing, control, and status of the bus. Data is transferred in 8-bit bytes using ASCII code. Communication is asynchronous and can support a range of data rates. The data lines are bi-directional, active low. One byte is transferred at a time.

5.2 IEEE-488 Bus Operation

Management of the bus is performed via five signal lines, as described below:

ATN (Attention)	When set, causes an instrument to respond to bus messages.
EOI (End or Identify)	When set, the last byte of a multibyte message has been placed on the bus. Also used to indicated a parallel poll.
IFC (Interface Clear)	When set, instrument interface is placed in a known preset state.
REN (Remote Enable)	When set, the instrument will enter the remote state when it receives its bus address.
SRQ (Service Request)	Can be set by the instrument as a result of a programmed condition.

Transfer of information is carried out using a three wire handshake. The three signals are described below:

DAV (Data Valid)	Can be set by a bus talker if the NRFD is not set and a data byte is ready to be transferred.
NRFD (Not Ready for Data)	Is set when a bus listener has not yet received valid data.
NDAC (Not Data Accepted)	Indicates that a listener has accepted the current data.

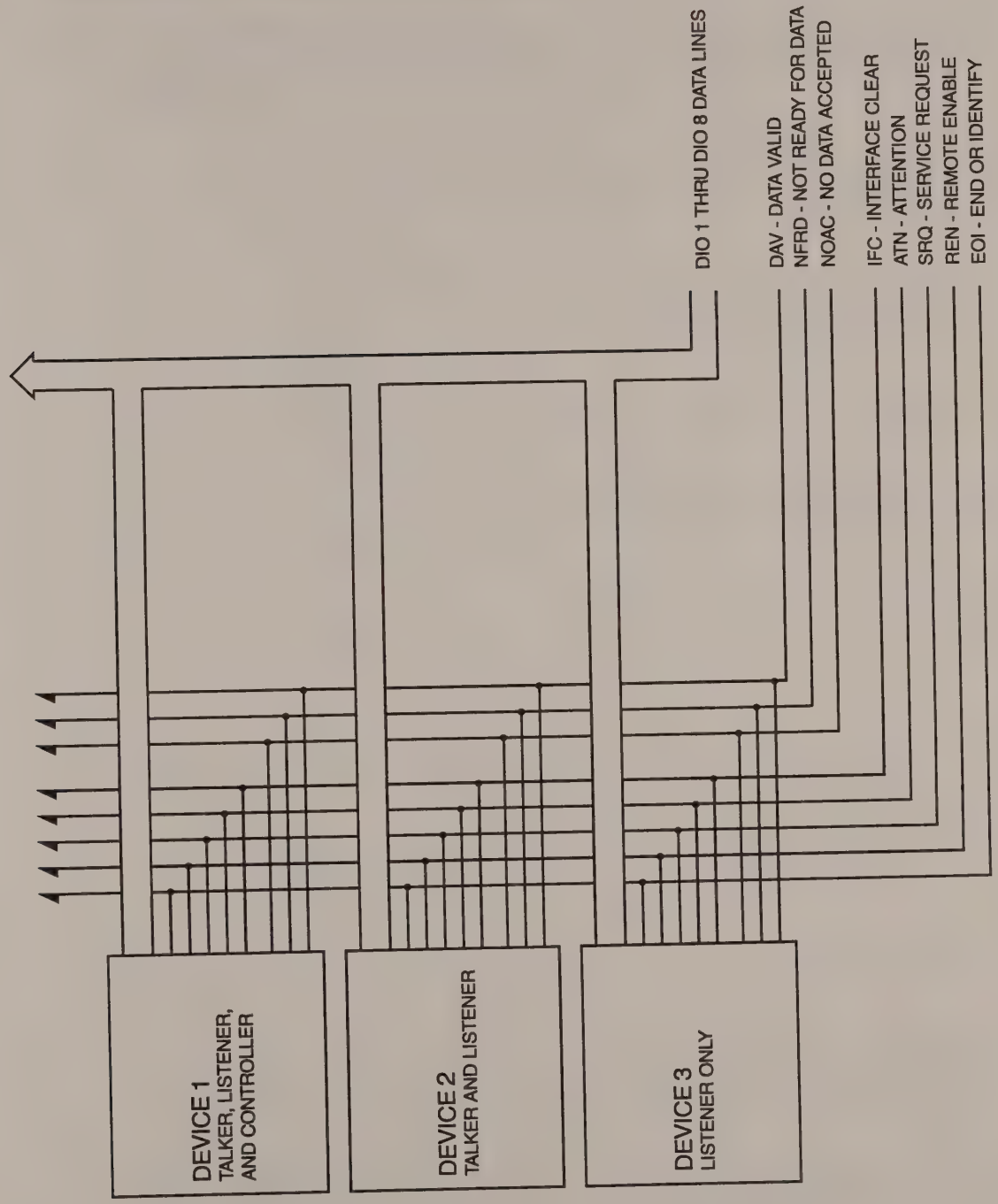


Figure 5-1. IEEE-488 Bus Interconnect Structure

5.3 MP-2500 as a Listener on the IEEE-488 Bus

The instrument has a built-in IEEE-488 interface which is configured as a listener. The MP-2500 will respond to commands on the IEEE-488 which are issued by an external controller. The interface characteristics are as follows:

1. Commands may be sent in upper, lower, or mixed case.
2. Any valid IEEE-488 command received by the MP-2500 will place it in remote operation. Any keyboard entry will return the instrument to local operation.
3. If local lockout (LLO) is issued, all front panel controls are disabled.
4. The IEEE-488 address is saved with the instrument configuration. Therefore, once it is set, it will remain the same until changed. Valid addresses are 1 to 30.
5. Commands can be concatenated into a single line, but must be separated by a semicolon (;).
6. The MP-2500 will generate a status response to each command it receives. When multiple commands are sent on a line, the response will be for the last command only.
7. All error messages to the VGA display are suppressed during remote operation.

Example of a command line with multiple commands:

```
OPEN Et100t6.sta; CH1; ST; CH2; ST
```

This command loads a file named "Et100t6.sta" and then starts Channels 1 and 2, sequentially.

If the file to be opened does not reside in the MP-2500 directory, the *OPEN* command should appear as follows:

```
OPEN C:\\DIRECTORY\\FILENAME.STA;
```

Commands must be structured to conform to the hierarchy shown in Tables 5-1 and 5-2.

The top level in the command hierarchy contains the Application commands. A file must be *OPEN*ed or a *NEW* file must be created. Optionally, the configuration and IEEE-488 address may be modified.

The second level of the command hierarchy contains the Document commands. The *CH*annel to which commands are to be issued must be specified. The *CH*annel command need not be issued again unless the channel number is to be changed. Optionally, the current file can be saved.

The third level of the command hierarchy includes the Channel commands. The *SEG*ment command must be specified before the channel can be modified. The *SEG*ment command need not be issued again unless the segment number is to be changed. All other Channel commands are optional, except *ST*art, which can be issued at any time.

The fourth level of the command hierarchy contains the Segment commands. The Path command must be issued before a path can be modified. Also, the *TD* command must be sent to set the time duration to a value greater than zero. All other Segment commands are optional.

The fifth level of the hierarchy includes the Path commands. After the *PATH* command has been issued, the specified path can be modified repeatedly without resending the *PATH* command. At least one path must be enabled to have an output from the channel.

Note that the *ST*art command can be sent while in the third, fourth, or fifth level, without disturbing the current position in the hierarchy.

For example, to modify path parameters in Channel 2, send the following:

```
CH 2; SEG 1; PATH 3; LOSS 5
PATH 4; DEL 0.02
```

Now, to modify Channel 1 path parameters, the channel, segment, and path must be specified:

```
CH 1; SEG 1; PATH 2; SPD 30
```

The following is an example program written in *QuickBasic*.

```
OPEN CDMA1.STA

CONFG2

CH1; SEG 1; TD 1; HR; MPH; CF 824.03; ATT 12
PATH 2; DOPL; SPD 55
PATH 3; RAY; LOSS 5
CH 2; SEG 1; TD 1; HR; MPH; CF 869.03
PATH 1; DOPL; SPD 55
PATH 2; RAY; SPD 55; DEL 3.2
ST; CH 1; ST
WAIT 200
SEG 1; PATH 3; LOSS 0
```

5.4 Remote Commands

The following pages provide a complete list of remote commands for the *Static Remote* and *Dynamic Remote* modes.

Table 5-1: Static Remote Commands

Command Type	Mnemonic	Parameter Type	Description
Application	OPEN xxx	char string	Open existing document with filename *xxx*
	NEWST		Open new static document with default values
	NEWD		Open new Dynamic document with default values
	CNFG x (Note 1)	int	Set the configuration $x = 1,2,3,4,5$
	ADDR x	int	Set the remote device address to *x*
	*IDN?		Returns *MP2500* or *MP2600*
	UD		Use Doppler
	US		Use Speed
	IF xxx	*OFF* or *ON*	Inserts the interference test filter
Document	SAV		Save the current settings under current filename
	SAVAS xxx	char string	Save the current settings under filename *xxx*
	CH *x* (Note 2)	int	Select Channel *x*
Channel	SING, CONT		Set run mode to *SINGLE RUN* or *CONTINUOUS RUN*
	MUL x	int	Set run mode to *MULTIPLE* with *x* runs
	ST, PSE, RST		*START, PAUSE*, or *STOP* the run
	FIL x	int	Set Rayleigh filter shape number to *x*
	AGC xxx	*OFF* or *ON*	Set Automatic Gain Control *OFF* or *ON*
	LD xxx	char string	Use live data file
	LDO		Disable live data
	PWOF x	float	Set output power offset to *x*
	ADDS		Add a segment with default settings to the end of the segment list
	REMS		Remove the currently selected segment
	SEG x	int	Select Segment *x*

Table 5-1: Static Remote Commands (Continued)

Command Type	Mnemonic	Parameter Type	Description
Segment	MPH, KPH, FPS, MPS		Set speed scale to *MILES/HR*, *KM/HR*, *FT/SEC*, or *METERS/SEC*
	SEC, MIN, HR		Set time scale to *SECONDS*, *MINUTES*, or *HOURS*
	CF x	float	Set center frequency to *x* (in MHz)
	INDEL x	float	Set initial delay to *x* (in µsec)
	ATT x	float	Set output attenuation to *x* (in dB)
	PWR x	float	Set output power to *x* (in dBm)
	TD x	int	Set time duration to *x*
	PATH x	int	Select Path *x*
Path	OFF, DOPL, RAY, RICE, LOG, SUZ, NAK		Set path type to *CLOSED*, *DOPPLER*, *RAYLEIGH*, *RICIAN*, *LOG-NORMAL*, *SUZUKI*, or *NAKAGAMI*
	SPD x	float	Set speed to *x*
	DOP x	float	Set Doppler to x
	DEL x	float	Set delay to *x* (in µsec)
	LOSS x	float	Set loss to *x* (in dB)
	PH x	int	Set the phase shift to *x* (in degrees)
	CORN x	int	Set correlation path to path *x*
	COR1N x	int	Set correlation path to channel 1: path *x*
	COR2N x	int	Set correlation path to channel 2: path *x*
	CORP x	int	Set correlation percent to *x*

Note 1 1 = Single; 2 = Diversity; 3 = Interference; 4 = Duplex; 5 = Doppler with common LO

Note 2 Specifying CH 1 is optional when using single channel configuration.

Table 5-2: Dynamic Remote Commands

Command Type	Mnemonic	Parameter Type	Description
Application	OPEN xxx	char string	Open existing document with filename *xxx*
	NEWST		Open new Static document with default values
	NEWD		Open new Dynamic document with default values
	CNFG x (Note 1)		Set the configuration $x = 1,2,3,4,5$
	*IDN?		Returns *MP2500* or *MP2600*
	ADDR x	int	Set the remote device address to *x*
	IF x	*OFF* or *ON*	Inserts the interference test filter
Document	SAV		Save the current settings under current filename
	SAVAS xxx	char string	Save the current settings under filename *xxx*
	SING, CONT		Set run mode to *SINGLE RUN* or *CONTINUOUS RUN*
	MUL x	int	Set run mode to *MULTIPLE* with *x* runs
	ST, PSE, RST		*START, PAUSE*, or *STOP* the run
	FIL x	int	Set Rayleigh filter shape number to *x*
	AGC xxx	*OFF* or *ON*	Set Automatic Gain Control *OFF* or *ON*
	ADDN		Add a node with default settings to the end of the segment list
	REMN		Remove the currently selected node
	NODE x	int	Select Node *x*
	REFL x	int	Select Reflector *x*
	MPH, KPH, FPS, MPS		Set speed scale to *MILES/HR, KM/HR, FT/SEC*, or *METERS/SEC*
	DIST *x*	float	Set maximum distance to *x*
Transmitter	TRAN x	int	Select transmitter 1 or 2
	TXP x	float	Set transmitter X position to *x*
	TYP x	float	Set transmitter Y position to *x*
	CF x	float	Set center frequency to *x* (in MHz)
	ATT x	float	set output attenuation to *x* (in dB)
Reflector	OFF, DOPL, RAY, LOG, SUZ		Set reflector type to *CLOSED, DOPPLER, RAYLEIGH, LOG-NORMAL, OR SUZUKI*
	RXP x	float	Set reflector X-position to *x*
	RYP x	float	Set reflector Y-position to *x*
	LOSS x	float	Set reflector loss to *x* (in dB)

Table 5-2: Dynamic Remote Commands (Continued)

Command Type	Mnemonic	Parameter Type	Description
Node	NXP x	float	Set node X-position to *x*
	NYP x	float	Set node Y-position to *x*
	NS x	float	Set node speed to *x*
Shadow	SH1XP x	float	Set first end point x position of shadow to *x*
	SH1YP x	float	Set first end point y position of shadow to *x*
	SH2XP x	float	Set 2nd end point x position of shadow to *x*
	SH2YP x	float	Set 2nd end point y position of shadow to *x*
	SH xxx	*OFF* or *ON*	Set shadow *OFF* or *ON*
	SHLOSS x	float	Set shadow loss to *x* (in dB)

5.5 Installing ISA Compatible Devices in the MP-2500

The MP-2500 signal processing hardware interfaces with the internal 486 computer via the ISA bus. Channel 1 occupies bus address 340 through 348, and Channel 2 occupies bus addresses 350 through 358. If an address conflict occurs involving optional hardware you installed in your MP-2500, consult the factory about changing the Channel 1 and Channel 2 addresses.

Section 6. Applications

This section describes several standard measurement applications to illustrate the use of the MP-2500.

6.1 CDMA Soft Hand-off Application

6.1.1 Channel Model Parameters and Characteristics

For the CDMA Soft Hand-off application, the MP-2500 standard channel simulator supports the channel model parameters and characteristics listed in Table 6-1.

Table 6-1: Channel Model Parameters and Characteristics

Fading	All paths are independently faded
Rayleigh power distribution	$F(P) = \begin{cases} 1 - e^{-P/P_{ave}} & P > 0 \\ 0 & P \le 0 \end{cases}$ where P is the signal power level and P_{ave} is the mean power level.
Level crossing rate, L(P)	$L(P) = \begin{cases} \sqrt{2\pi (P/P_{ave})} f_d e^{-P/P_{ave}} & P > 0 \\ 0 & P \le 0 \end{cases}$ where f_d is the Doppler frequency offset associated with the simulated vehicle speed and is given by: $f_d = \left(\frac{v}{c}\right)(f_c \cdot \cos\alpha)$ f_c is the carrier frequency, v is the vehicle speed, c is the speed of light in a vacuum, and α is the angle of arrival.
Power spectral density, S(f)	$S(f) = \begin{cases} \frac{1}{\sqrt{1 - \left(\frac{f - f_c}{f_d}\right)^2}} & f_c - f_d \le f \le f_c + f_d \\ 0 & \text{Otherwise} \end{cases}$

Table 6-1: Channel Model Parameters and Characteristics (Continued)

Correlation coefficient of the unwrapped phase[1], r(t)	$r(t) = \frac{3}{2\pi}\sin^{-1}h(t) + 6\{\frac{1}{2\pi}\sin^{-1}[h(t)]^2\} - \frac{3}{4\pi^2}\sum_{n=1}^{\infty}\frac{[h(t)]^{2n}}{n^2}$ where $h(t) = t_o(2\pi f_d t)[\bullet]\frac{\sin(2\pi f_d t)}{2\pi f_d t}$ • is the convolution function. The correlation coefficient is shown in Figure 6-1.

[1]The term "unwrapped" refers to the continuous nature of the phase; that is, with no discontinuities of 2π.

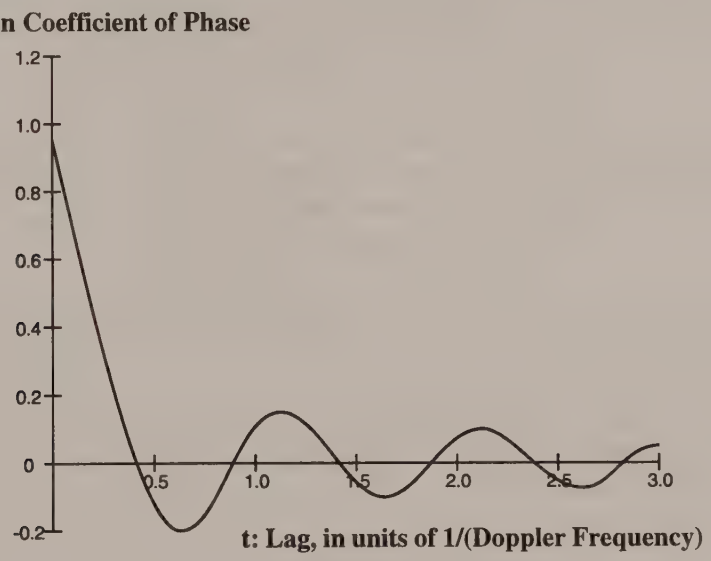


Figure 6-1. Correlation Coefficient of Phase

6.1.2 Standard Conditions and Tolerances

The MP-2500 channel simulator supports the standard conditions and tolerances of the channel model parameters listed in Table 6-2.

Table 6-2: Standard Conditions and Tolerances

Doppler frequency offset	Vehicle Speed v (km/hr)	Mobile Station f_d
	8	6.53 Hz ±5%
	30	24.5 Hz ±5%
	100	81.67 Hz ±5%
Power distribution function, F(P)	For mean power levels from 10 dB above the mean power level to 20 dB below the mean power level	Within ±1 dB of calculated
	For mean power levels from 20 dB below the mean power level to 30 dB below the mean power level	Within ±5 dB of calculated
Level crossing rate, L(P)	For mean power levels from 3 dB above the mean power level to 30 dB below the mean power level	Within ±10% of calculated
Measured power spectral density, S(f), around the carrier at frequency f_c	At frequency offsets $\|f - f_c\| = f_d$	The maximum power spectral density, S(f), exceeds $S(f_c)$ by at least 6 dB.
	For frequency offsets $\|f - f_c\| > 2f_d$	The maximum power spectral density, S(f) is at least 30 dB less than $S(f_c)$.
Simulated Doppler frequency, f_d	Computed from the measured S(f) as: $f_d = \left[\frac{2\int (f-f_c)^2 S(f)\, df}{\int S(f)\, df}\right]^{1/2}$	
Measured correlation coefficient of the unwrapped phase, r(t)	At a lag of $0.05/f_d$	0.8 ±0.1
	At a lag of $0.15/f_d$	0.5 ±0.1

6.1.3 Supported Configurations

The standard channel simulator supports the configurations specified in Table 6-3. The functional set-up for traffic channel tests in the Soft Hand-off configuration is illustrated in Figure 6-2.

Table 6-3: Standard Channel Simulator Configurations

Channel Simulator Configuration	1	2	3	4	5
Vehicle Speed [km/hr]	8	30	30	100	0
Number of Paths	2	2	1	3	2
Path 2 Power (relative to Path 1) [dB]	0	0	N/A	0	0
Path 3 Power (relative to Path 1) [dB]	N/A	N/A	N/A	-3	N/A
Delay from Path 1 to Input [µs]	0	0	0	0	0
Delay from Path 2 to Input [µs]	2	2	N/A	2	2
Delay from Path 3 to Input [µs]	N/A	N/A	N/A	14.5	N/A

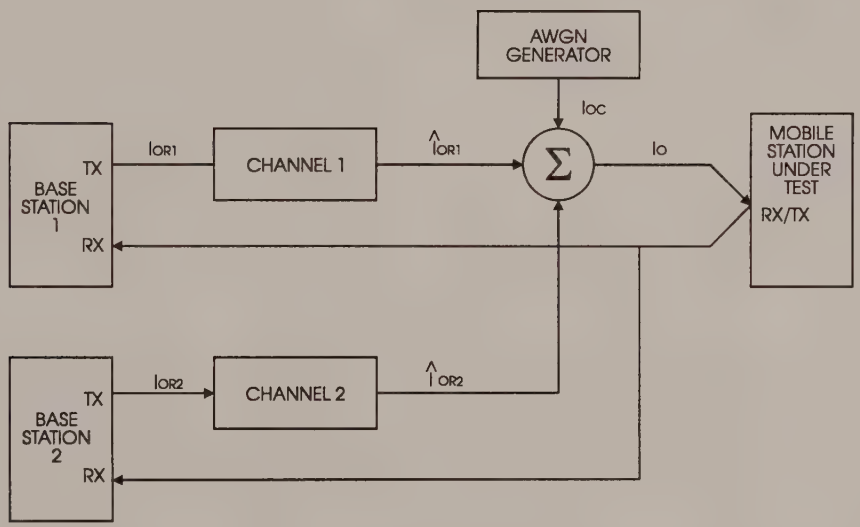


Figure 6-2. Functional Set-up for Traffic Channel Tests in Soft Hand-off Application

6.2 GSM Adjacent Channel or Interferer Application

Figure 6-3 illustrates the standard test configuration for radio measurements.

6.2.1 Simple Wideband Propagation Model

Radio propagation in the mobile radio environment is described by highly dispersive multipath caused by reflection and scattering. The paths between base stations and mobile stations may be considered to consist of large reflectors and/or scatterers some distance from the mobile receiver, which generate a number of waves that arrive in the vicinity of the receiver with random amplitudes and delays.

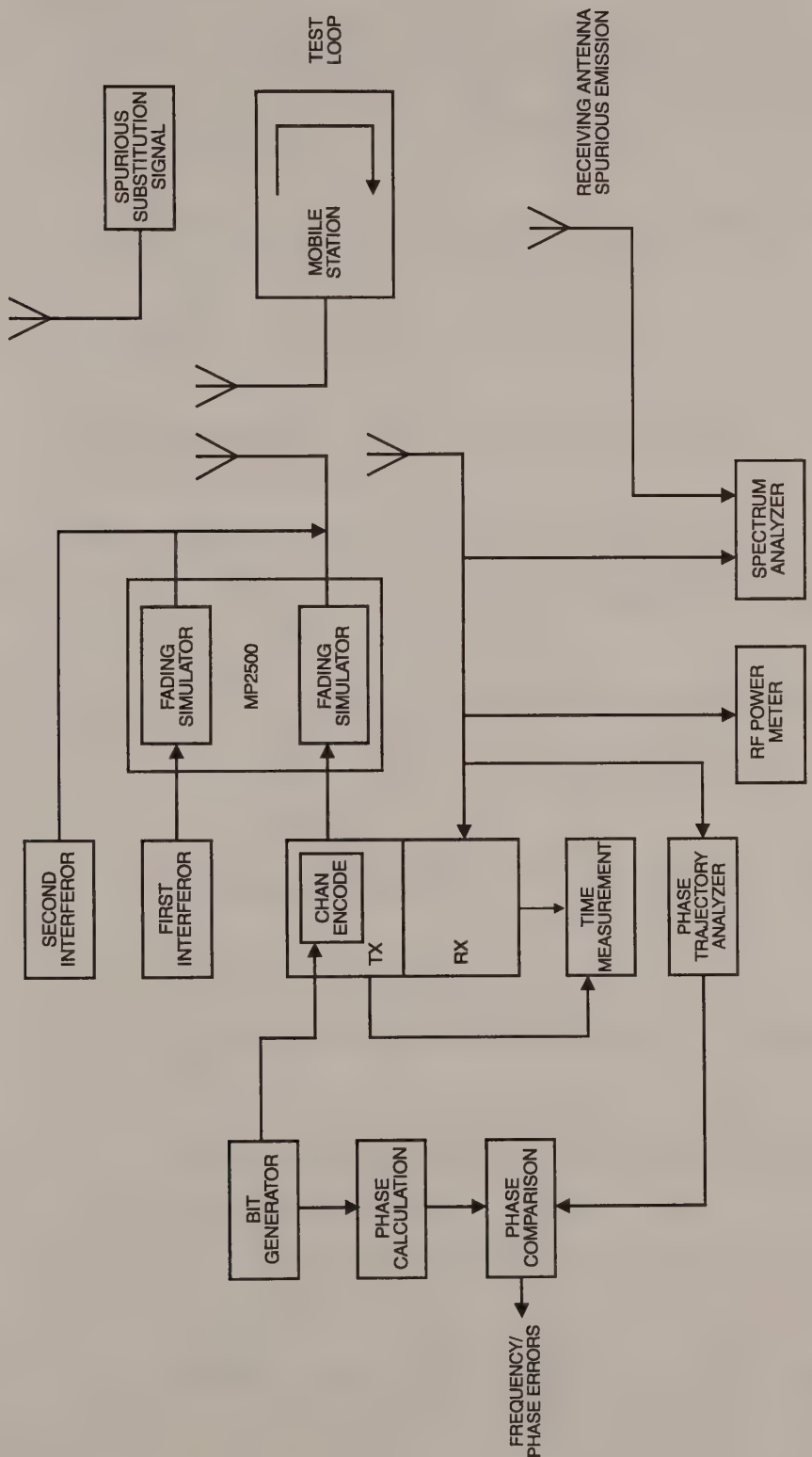


Figure 6-3. Configuration for Radio Measurements

Close to the receiver, these paths are further randomized by local reflections or diffractions. Since the mobile receiver will be moving, the angle of arrival must also be taken into account, since it affects the Doppler shift associated with a wave arriving from a particular direction. Echoes of identical delays arise from reflectors located on an ellipse.

The multipath phenomenon may be described in the following way in terms of the time delays and the Doppler shifts associated with each delay:

$$z(t) = \int\int_{R^2} y(t-T)\, S(T,f) e^{(2i\pi ft)}\, (df)\, dT$$

where the terms on the right-hand side represent the delayed signals, their amplitudes and Doppler spectra.

It has been shown that the criterion for wide sense stationary is satisfied for distances of about 10 meters. Based on the wide sense stationary uncorrelated scattering (WSSUS) model, the average delay profiles and the Doppler spectra are necessary to simulate the radio channel.

In order to allow practical simulation, the different propagation models will be presented here in the following terms:

(1) a discrete number of taps, each determined by their time delay and average power

(2) the Rayleigh distributed amplitude of each tap, varying according to a Doppler spectrum S(f).

6.2.2 Doppler Spectrum Types

In this section we define the two types of Doppler spectra that will be used for the modeling of the channel. Throughout this discussion the following abbreviations will be used:

$f_d = v/\lambda$, represents the maximum Doppler shift, with v representing the vehicle speed (in meters per second), and λ the wavelength (in meters).

The following types are defined:

(1) CLASS is the classical Doppler spectrum and will be used in all but one case:

$$\text{(CLASS)} \quad S(f) = A/\sqrt{\left(1-(f/f_d)^2\right)} \qquad for\ f \in 1-f_d, f_d$$

(2) RICE is the sum of a classical Doppler spectrum and one direct path, such that the total multipath contribution is equal to that of the direct path. This spectrum is used for the shortest path of the RA model:

$$\text{(RICE)} \quad S(f) = 0.41 / \left[2\pi f_d \sqrt{1 - (f/f_d)^2} \right] + 0.91\delta(f - 0.7f_d)$$

$$\text{for } f \in 1 - f_d, f_d$$

6.2.3 Propagation Models

Table 6-4 through Table 6-9 define the propagation models that are mentioned in the main body of Rec. 05.05. These models are referred to as NAME*x*, where NAME is the name of the particular model (as indicated in the title of the table) and *x* is the vehicle speed (in km/h) which impacts on the definition of f_c (see 6.2.2), and hence, on the Doppler spectra.

These models are usually defined by 12-tap settings; however, according to the simulators available, it may not be possible to simulate the complete model. Therefore, a reduced configuration my be used, in particular, for the multipath simulation of an interfering signal. Whenever possible, the full configuration should be used. For each model, two equivalent application alternative tap settings [indicated respectively by (1) and (2) in the appropriate columns] are given.

Table 6-4: Typical Case for Rural Area (RA*x*) — 6-Tap Setting

Tap Number	Relative Time (μs)		Average Relative Power (dB)		Doppler Spectrum
	(1)	(2)	(1)	(2)	
1	0.0	0.0	0.0	0.0	RICE
2	0.1	0.2	-4.0	-2.0	CLASS
3	0.2	0.4	-8.0	-10.0	CLASS
4	0.3	0.6	-12.0	-20.0	CLASS
5	0.4	—	-16.0	—	CLASS
6	0.5	—	-20.0	—	CLASS

Table 6-5: Typical Case for Hilly Terrain (HT*x*) —12-Tap Setting

Tap Number	Relative Time (µs)		Average Relative Power (dB)		Doppler Spectrum
	(1)	(2)	(1)	(2)	
1	0.0	0.0	-10.0	-10.0	CLASS
2	0.1	0.2	-8.0	-8.0	CLASS
3	0.3	0.4	-6.0	-6.0	CLASS
4	0.5	0.6	-4.0	-4.0	CLASS
5	0.7	0.8	0.0	0.0	CLASS
6	1.0	2.0	0.0	0.0	CLASS
7	1.3	2.4	-4.0	-4.0	CLASS
8	15.0	15.0	-8.0	-8.0	CLASS
9	15.2	15.2	-9.0	-9.0	CLASS
10	15.7	15.8	-10.0	-10.0	CLASS
11	17.2	17.2	-12.0	-12.0	CLASS
12	20.0	20.0	-14.0	-14.0	CLASS

Table 6-6: Typical Case for Hilly Terrain — Reduced Setting (6-Tap)

Tap Number	Relative Time (µs)		Average Relative Power (dB)		Doppler Spectrum
	(1)	(2)	(1)	(2)	
1	0.0	0.0	0.0	0.0	CLASS
2	0.1	0.2	-1.5	-2.0	CLASS
3	0.3	0.4	-4.5	-4.0	CLASS
4	0.5	0.6	-7.5	-7.0	CLASS
5	15.0	15.0	-8.0	-6.0	CLASS
6	17.2	17.2	-17.7	-12.0	CLASS

Table 6-7: Typical Case for Urban Area (TU*x*) —12-Tap Setting

Tap Number	Relative Time (μs)		Average Relative Power (dB)		Doppler Spectrum
	(1)	(2)	(1)	(2)	
1	0.0	0.0	-4.0	-4.0	CLASS
2	0.1	0.2	-3.0	-3.0	CLASS
3	0.3	0.4	0.0	0.0	CLASS
4	0.5	0.6	-2.6	-2.0	CLASS
5	0.8	0.8	-3.0	-3.0	CLASS
6	1.1	1.2	-5.0	-5.0	CLASS
7	1.3	1.4	-7.0	-7.0	CLASS
8	1.7	1.8	-5.0	-5.0	CLASS
9	2.3	2.4	-6.5	-6.0	CLASS
10	3.1	3.0	-8.6	-9.0	CLASS
11	3.2	3.2	-11.0	-11.0	CLASS
12	5.0	5.0	-10.0	-10.0	CLASS

Table 6-8: Typical Case for Urban Area— Reduced Setting (6-Tap)

Tap Number	Relative Time (μs)		Average Relative Power (dB)		Doppler Spectrum
	(1)	(2)	(1)	(2)	
1	0.0	0.0	-3.0	-3.0	CLASS
2	0.2	0.2	0.0	0.0	CLASS
3	0.5	0.6	-2.0	-2.0	CLASS
4	1.6	1.6	-6.0	-6.0	CLASS
5	2.3	2.4	-8.0	-8.0	CLASS
6	5.0	5.0	-10.0	-10.0	CLASS

Table 6-9: Profile for Equalization Test— 6-Tap Setting

Tap Number	Relative Time (µs)	Average Relative Power (dB)	Doppler Spectrum
	(1)	(1)	
1	0.0	0.0	CLASS
2	3.2	0.0	CLASS
3	6.4	0.0	CLASS
4	9.6	0.0	CLASS
5	12.8	0.0	CLASS
6	16.0	0.0	CLASS

6.3 Doppler Filter Selection

Four filter shapes are available to define the spectral power density of the Gaussian noise that is used to generate the Rayleigh distribution (Figure 6-4).

- Shape #1 is required for testing of most systems, in particular CDMA, GSM and DCS. It generates 6 dB of peaking at offsets equal to the Doppler frequency. This shape is the result of an assumed scenario in which there are uniformly distributed reflector patterns and omnidirectional antennas on both the vehicle and base station.
- Shape #2 is similar to Shape #1, except the peaking is limited to 3 dB.
- Shape #3 is a maximally flat passband response.
- Shape #4 is a Gaussian passband response.

6.4 Selecting the Proper Configuration for Your Application

The MP-2500 has flexible internal signal routing to accommodate single channel, diversity, interference, and duplex testing. This flexibility is achieved by using switching networks at the RF input, the LO input, and the RF output.

6.4.1 Single Channel Configuration

In single channel configuration, all of the installed paths operate on a single channel. The RF input, LO input, and RF output all appear on Channel 1.

6.4.2 Diversity Configuration

The diversity configuration routes a single RF input and a single LO input to both channels. The paths in each channel are controlled independently. Two outputs are available, one from each channel. This configuration enables one signal source to accommodate space diversity testing.

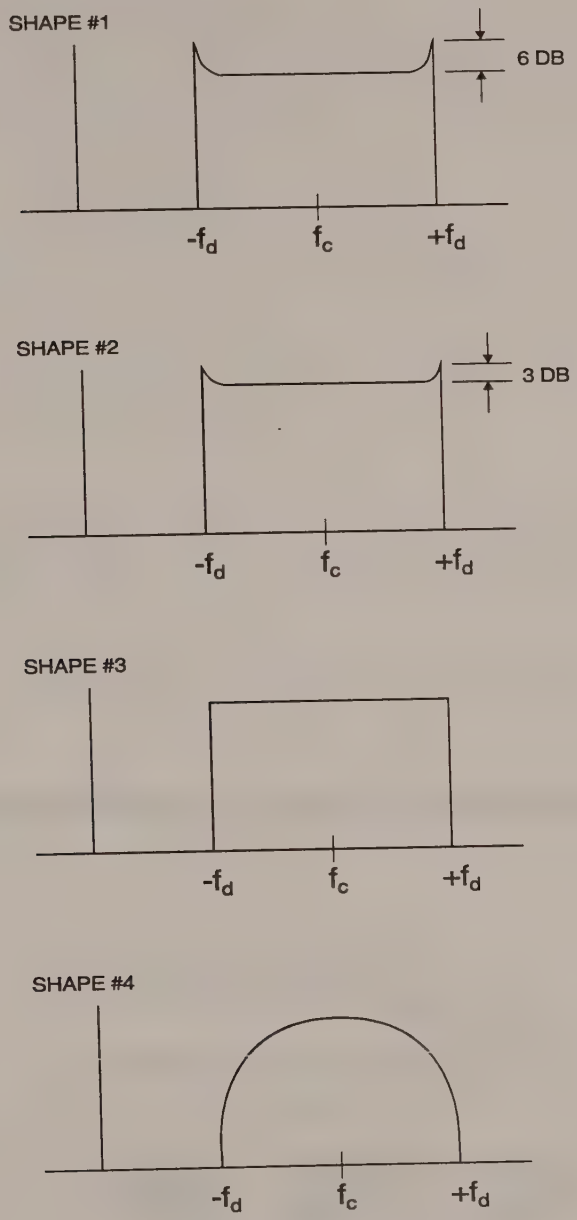


Figure 6-4. Filter Shapes

6.4.3 Interference (C/I) Configuration

The interference configuration requires one LO and two RF inputs. The paths in each channel are controlled independently. The signals from Channel 1 and 2 are combined into a single RF output. This configuration can be used for both co-channel and adjacent channel interference. For adjacent channel interference both signals must be contained within the 6 MHz bandwidth of the MP-2500.

6.4.4 Duplex Configuration

The duplex configuration provides independent RF inputs and output for each of the channels. It can be used for duplex testing, in which the uplink and downlink frequencies differ. This configuration offers maximum flexibility.

6.4.5 Dual/Common LO

The Dual/Common LO configuration is identical to the duplex configuration, except that the Channel 1 LO input is routed internally to both Channel 1 and Channel 2. This configuration makes it possible for you to use the MP-2500 with one LO to test duplex applications in which the uplink and downlink frequencies are within the 6 MHz bandwidth (e.g., DECT).

6.5 Creating a New Static File

The MP-2500 contains a number of pre-installed data files that support testing to several wireless communication standards (NADC, CDMA, GSM, etc.). In some instances, however, it will be necessary to create your own data files to accurately reflect your test environment.

To create a new file, start the *mp2500.exe* program and click on the *New Static* button in the MP-2500 Main Display (Figure 6-5).

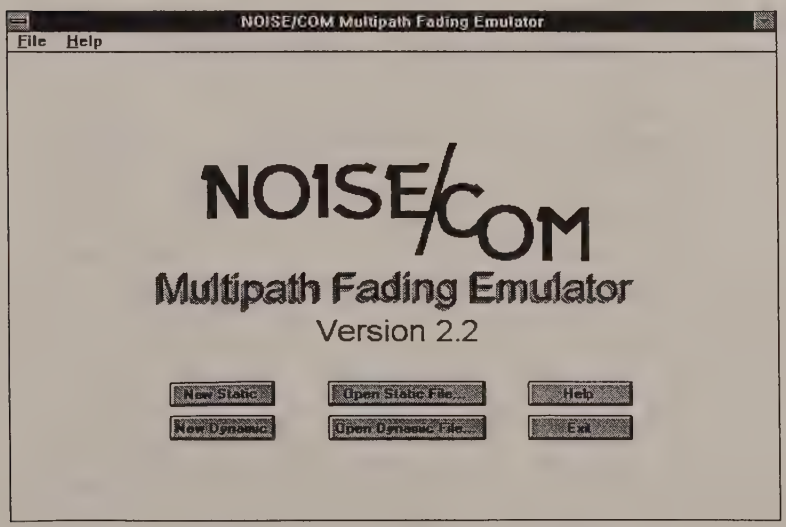


Figure 6-5. MP-2500 Main Display

If the *mp2500.exe* program is already running, select *New Static* from the *File* menu. The default *Static* mode parameter screen will appear with *Untitled* as the file name and a blank space in the description block (Figure 6-6). Later, when you retrieve the file to edit or run a test, the name you have assigned to the file will appear in the file name box, automatically.

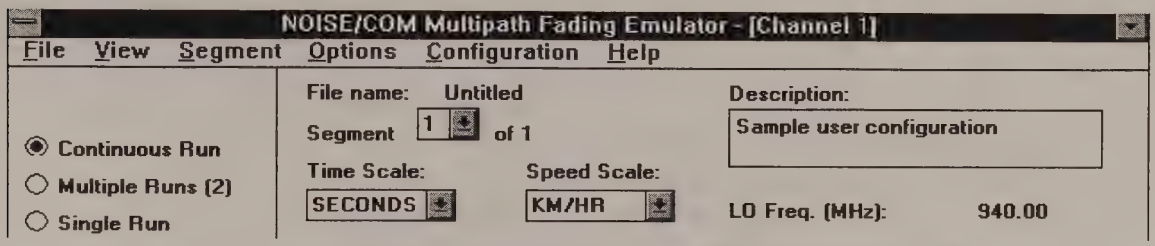


Figure 6-6. Enter the File Description for a New Static File

Select *View, Channel 1* to set the parameters for Channel 1. You can add a description of the data file by clicking in the *Description* box and typing a phrase such as "Sample user configuration." When you have set the test parameters for Channel 1, select *Channel 2* from the *View* menu to set the parameters for Channel 2.

6.5.1 Example

As an example of the procedure used to complete the parameter page for a new static file, duplicate the recommended test parameters of IS-98 (CDMA), which has been stored in the MP-2500 as cdma-ms4.sta. The recommended test parameters are presented in Table 6-10. (These values are derived from the standard channel simulator configurations presented earlier in Table 6-3.)

Table 6-10: IS-98 CDMA Parameters

Description	Value
RF input signal center frequency	881.45 MHz
Duration of test	20 hours
Initial delay	None
Output attenuation	0 dB
Vehicle speed	100 km/h
Number of paths	3
Path 2 relative loss power	0 dB
Path 3 relative loss power	3 dB
Path delay	0 µs
Path 2 relative delay	2 µs
Path 3 relative delay	14.5 µs
Phase offset (for all paths)	None
Correlation path / % (for all)	None

Referring to Figure 6-7, enter the recommended test parameters into the data file as follows:

(1) Center Frequency

Click on the *Center Frequency* box, type *881.45,* and press *Enter.* You may also use the arrow keys at the opposite ends of the *Center Frequency* slide bar to adjust the coarse frequency, but you must use the keyboard to enter the fractional component. Notice that the LO frequency changes automatically to reflect the 140 MHz offset.

(2) Time Duration

Click on the *Time Duration* box and change the duration of the test to *20.* Alternatively, you may use the arrow keys at the opposite ends of the *Time Duration* slide bar to adjust the test duration. Next, click on the up arrow to the right of the *Time Scale* box and select *HOURS.*

No adjustment is required for either *Initial Delay* or *Output Attenuation.*

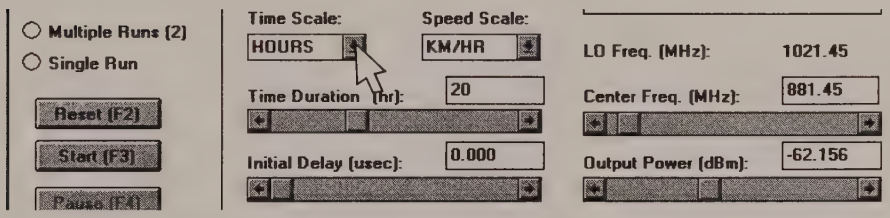


Figure 6-7. Setting the Center Frequency and Time Duration

(3) Path Parameters

Before adjusting the path parameters, click on the arrow to the right of the *Speed Scale* and select *KM/HR* (if necessary). To set the parameters for each path, double click on the path number in the Path Parameter table at the bottom of the display (Figure 6-8) to bring up the *Change Path X Parameters* dialog box (Figure 6-9).

Path #	Spectrum Type	Speed (km/hr)	Loss (dB)	Delay (us)	Offset (degrees)	Correlation Path %
1	Off	0.000	0.00	0.000	0.0	None
2	Off	0.000	0.00	0.000	0.0	None
3	Off	0.000	0.00	0.000	0.0	None
4	Off	0.000	0.00	0.000	0.0	None
5	Off	0.000	0.00	0.000	0.0	None
6	Off	0.000	0.00	0.000	0.0	None

Figure 6-8. Path Parameter Table

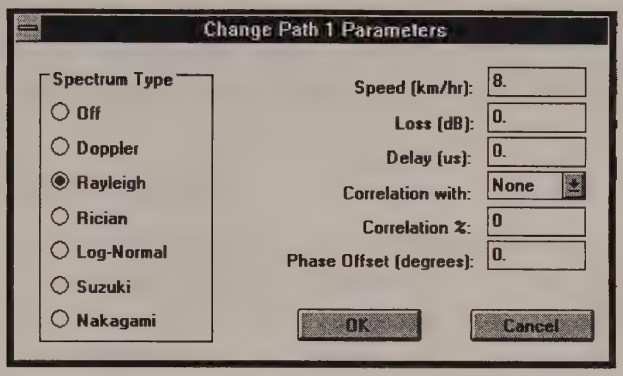


Figure 6-9. Change Path *X* Parameters Dialog Box

Use the Change Path *X* Parameters Box to enter the following selections for Path 1:

Spectrum type:	Rayleigh
Speed:	100 km/hr
Loss:	0.00 dB
Delay:	0.000 µs
Offset:	0.00 degrees
Correlation:	None

Click on the *OK* button to enter your selections. Repeat this procedure for Paths 2 and 3, noting the following differences:

Path 2 Delay	2 µsec
Path 3 Loss	3 dB
Path 3 Delay	14.5 µs

All other paths should be turned off.

After you have set the path parameters for Channels 1 and 2, verify the results by selecting *View, Hardware Setup*. If you compare the path parameters you have entered with the parameters defined in *cdma4.sta* file, the two sets of parameters should be identical.

To run the simulation, choose *Continuous Run, Multiple Runs,* or *Single Run* and press *Start* or *F3*.

6.6 Modifying a Static File

To modify an existing file, open the file, modify the display as required, and use the *Save* command to overwrite the existing file or the *Save As* command to create a new file.

6.7 Creating a Dynamic File

The *Dynamic* mode enables you to simulate various multipath effects, including co-channel and adjacent channel interference. The MP-2500 emulates a multipath environment by placing a two-dimensional graphical representation of a mobile transceiver, an RF shadow, base stations, and reflectors on a scalable map.

6.7.1 Procedures

To create a new dynamic file, click on the *New Dynamic* button in the start-up screen (Figure 6-5) and the *Dynamic Parameter View* (partially illustrated in Figure 6-10) will appear. The default setup consists of two nodes, two base stations (transmitters), and five reflectors.

(1) Node Parameters

The node parameters are listed in a table in the upper-right segment of the display. You can adjust the node settings by double-clicking on the appropriate node number and updating the values in the *Change Node X Parameters* dialog box (Figure 6-11). Use the *Tab* key to move the cursor between parameter boxes. Press the *OK* button to enter your selections.

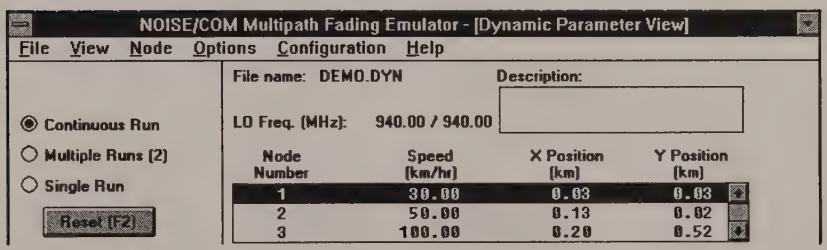


Figure 6-10. Node Parameter Table

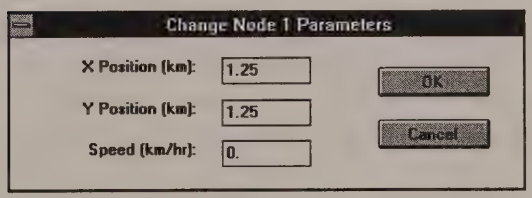


Figure 6-11. Change Node X Parameters to Dialog Box

(2) Transmitter Parameters

The default setup in the *Dynamic* mode is the *Duplex* configuration, which includes two transmitters. If you only require one transmitter, select *Configuration, Single Channel.* The transmitter parameters appear in a table immediately below the node table (Figure 6-12).

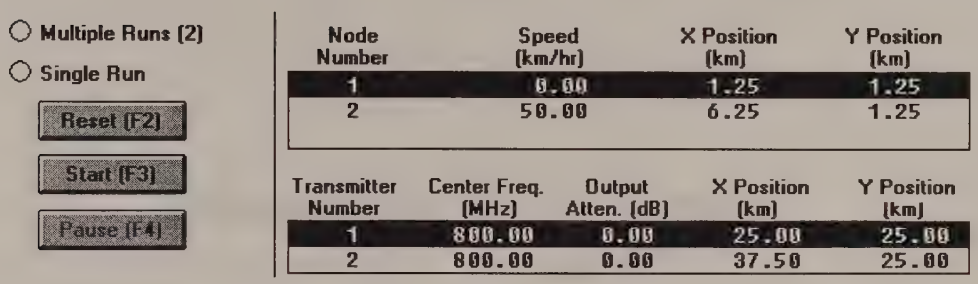


Figure 6-12. Base Station Transmitter Parameter Table

You can set transmitter parameters, such as RF center frequency, output attenuation, and location, by double-clicking on the transmitter number to view the *Change System X Parameters* dialog box (Figure 6-13).

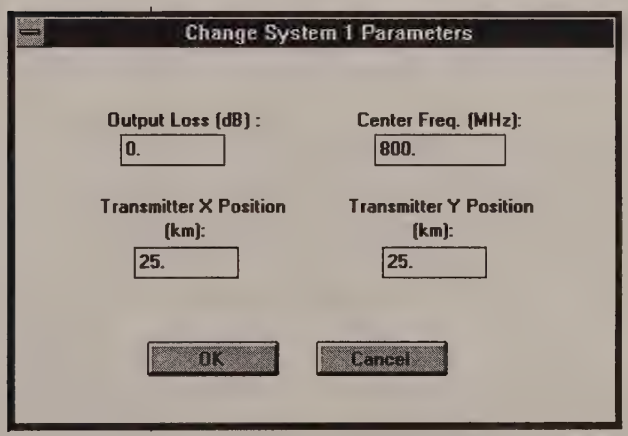


Figure 6-1 3. Change System X Parameters Dialog Bo x

(3) Reflector Parameters

Set the stationary reflector parameters by double-clicking on the reflector number in the Reflector Parameter Table (Figure 6-14) to view the *Change System X Parameters* dialog box (Figure 6-15).

Reflector Number	Spectrum Type	Reflector Loss (dB)	X Position (km)	Y Position (km)
1	Rayleigh	0.00	0.40	0.87
2	Rician	0.00	0.35	0.18
3	Log-Norm	0.00	0.81	0.72
4	Doppler	0.00	0.58	0.24
5	Suzuki	0.00	0.33	0.75

Figure 6-14. Reflector Parameter Table

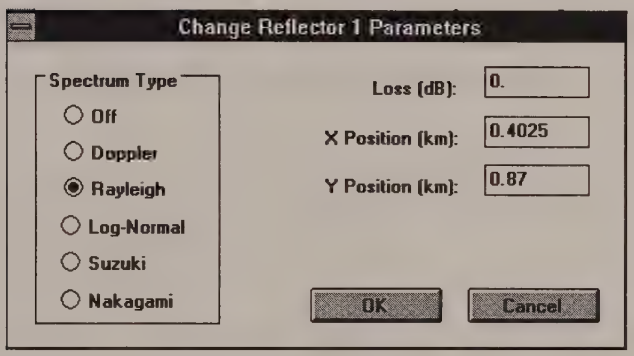


Figure 6-1 5. Change Reflector ***X* Parameters Dialog Box**

(4) Adding New Nodes

You can add up to nine new nodes by clicking on *Node, Add* in the *Dynamic Parameter View* (Figure 6-10). Alternatively, you can add new nodes by highlighting the last node number and double clicking at the position you wish to locate the new node. A new node and path will be created automatically.

6.7.2 Simulation Map

Note that the node, transmitter, and reflector parameter settings can be accomplished in the *Simulation Map* mode (see Section 3). With the simulation map, you can easily change the location of nodes, base stations, reflectors, and shadows by clicking and dragging each object to the desired position on the map. You can also change object parameters by double clicking on the object to invoke a dialog box.

6.7.3 Run Time Table

The Run Time Table (Figure 6-16) enables you to observe the parameters as they change during a run. The Run Time Table displays how the Doppler frequency, path loss, and delay vary dynamically for the signal path reflected by each reflector, as the mobile transceiver (vehicle) travels through the nodes.

Run Time Parameters			
Path	Doppler (Hz)	Loss (dB)	Delay (us)
DIRECT	0.701	0.00	0.000
	0.830	0.00	0.000
1	0.000	30.00	0.000
	0.000	30.00	0.000
2	0.000	30.00	0.000
	0.000	30.00	0.000
3	0.000	30.00	0.000
	0.000	30.00	0.000
4	0.000	30.00	0.000
	0.000	30.00	0.000
5	0.000	30.00	0.000
	0.000	30.00	0.000

Figure 6-16. Run Time Parameter Table

To view the Run Time Table during a *Dynamic Mode* run, select *View, Run Time Table*. To remove the Run Time Table, select it again from the *View* menu. Note that the *Direct* path in the Run Time Table is the unreflected propagation path from the transmitter, and, therefore, the loss and delay values are fixed at zero.

6.8 Using the Live Data File Capability in the Static Mode

The MP-2500 can update path parameters according to a user generated data file, instead of using the *Speed*, *Attenuation*, and *Delay* values entered in the path table of the *Static* mode *Parameter* view. The data file is activated by selecting *Live Data* from the *Options* menu. A prompt will appear for you to enter the name of the data file. Data files must have the extension *.DAT*.

When a valid data file has been selected, the affected parameters will be replaced by the word *Live* on the display. The spectrum type for the path will still be controlled by the parameter table entry. Channels 1 and 2 can simultaneously run the same or different live data files.

The live data file provides you with the flexibility to program each path independently. The path parameters will be updated at user selected time intervals. The minimum time between updates is 100 milliseconds. The resolution of the updates is ±56 milliseconds.

6.8.1 Generating a Live Data File

Live data is stored in an ASCII file in the MP-2500 directory on drive *c:*. The file must be generated using the format illustrated in Table 6-11.

Table 6-11: Live Data File Format

Line No.	Entry	Description
1	NUMBER: xxx	xxx is the number of data lines to follow for each parameter set.
2	INTERVAL: xx.x	xx.x is the number of seconds between the execution of each data line.
3	PATHS: x x x x	x x x are the path numbers of the paths that are affected by the parameters in the next line.
4	PARAMETERS: DELAY DOPPLER LOSS	List here the parameters that will be changed by the live data file. (If a parameter will not change, do not enter it in this line.)
5	Xxxxxxxx	Enter the actual data values. One value must be entered for each parameter specified in line 4.

The number of data lines must correspond to the data value entered in line 1.

To apply different parameter values to another path or paths, simply enter additional PATHS and PARAMETERS lines in the data file.

The following code is an example of a live data file:

```
NUMBER: 5
INTERVAL: 10.0
PATHS: 1 2
PARAMETERS: DELAY DOPPLER LOSS
1.000  -120.000  6.00
2.000  -220.000  7.00
3.000  -320.000  8.000
4.000  -420.000  9.00
5.000  -520.000  10.00
PATHS: 4 5
PARAMETERS: DELAY
8.000
8.100
8.200
8.300
8.400
```

Notes:

(1) INTERVAL specifies the time in seconds before the next sample is sent to the DSP. Minimum time is 0.1 seconds. Resolution is ±0.056 seconds.

(2) Use spaces to separate the path numbers after the title PATH.

(3) Use spaces to separate the parameters after the title PARAMETERS. Parameters can be listed in any order, but the data that follows must be presented in the order of the parameter list.

(4) On each data line, separate the data items with single spaces.

(5) Include as many PATHS and PARAMETERS lists as necessary. The number of samples must always agree with the number in the first line.

6.9 Using the Synthesized Local Oscillator (Option 8)

6.9.1 Synthesizer Components

Option 8 includes the following hardware.

(1) Synthesizer driver board

(2) 25-conductor ribbon cable assembly

(3) 6-foot cable with 25-pin subminiature (male) D-connectors (two cables required for dual controls)

(4) AC line cord

(5) Synthesizer assembly

Items (1) and (2) are installed inside the MP-2500. Item (3) will be used to interconnect the MP-2500 to the synthesizer assembly.

6.9.2 Connecting the Synthesizer Control Bus Cable

To install the control cable(s) between the synthesizer and the MP-2500, proceed as follows:

(1) Connect the 6-foot control cable to the 25-pin D-connector in Slot 9 (on the MP-2500 rear panel).

(2) For synthesizer units equipped with a single synthesizer, connect the other end of the control cable to the 25-pin D-connector labelled *Synthesizer #1* on the rear of the synthesizer.

(3) For synthesizer units equipped with two synthesizers, connect a second control cable between the 25-pin D-connector in Slot 6 to the D-connector labelled *Synthesizer #2* on the rear of the synthesizer unit.

6.9.3 Applying AC Power to the Synthesizer Unit

To select the appropriate line voltage and apply power to the synthesizer, proceed as follows (see Figure 3-3, Item 1):

(1) Slide the plastic safety cover covering the voltage selector to the left and over the power plug to expose the voltage selector.

(2) If the value shown on the selector plate does not correspond to the proper line voltage, pull the selector plate straight out to remove it from the plug assembly.

(3) Re-insert the selector so that the correct voltage is visible on the selector plate.

(4) Slide the plastic safety cover over the voltage selector plate.

(5) Apply AC power to the synthesizer using the supplied AC line cord.

(6) Turn on the power switch and observe that the power indicator on the synthesizer front panel is illuminated.

6.9.4 Connecting the RF Cables

To connect the RF cable(s) between the synthesizer and the MP-2500, proceed as follows:

(1) For synthesizer units equipped with a single synthesizer, connect the synthesizer RF output port labelled *CHANNEL 1 LO (+10 dBm)* to the MP-2500 port labelled *Channel 1 LO*.

(2) For synthesizer units equipped with two synthesizers, also connect the synthesizer RF output port labelled *CHANNEL 2 LO (+10 dBm)* to the MP-2500 port labelled *Channel 2 LO*.

6.9.5 Verifying the Synthesizer Operation

To verify the operation of the synthesizer, proceed as follows:

(1) Connect a suitable spectrum analyzer to the *Channel 1 Sample* output of the synthesizer.

(2) Adjust the analyzer for a center frequency of 960 MHz and a span of 1 MHz.

(3) Turn on the MP-2500 and select *New Static* from the Main Menu.

(4) Select Channel 1 from the *View* menu (if necessary).

(5) Set the *Time Duration* control to approximately 20 seconds.

(6) Set the center frequency to 820 MHz.

(7) Press the *Start* button (or *F3*) on the MP-2500 display and observe that the synthesizer Channel 1 output signal is centered in the analyzer display.

(8) For synthesizer units equipped with two synthesizers, select Channel 2 from the *View* menu.

(9) Connect the spectrum analyzer input to the *Channel 2 Sample* output of the synthesizer.

(10) Set the *Time Duration* control to approximately 20 seconds.

(11) Set the center frequency to 820 MHz.

(12) Press the *Start* button (or *F3*) on the MP-2500 display and observe that the synthesizer Channel 2 output signal is centered in the analyzer display.

6.10 Using the Duplexer Option (Option 5)

This option is contained in a connectorized enclosure which provides the MP-2500 with duplex capability. This enables the MP-2500 to be connected directly to a duplex device such as a mobile phone without external circuitry. Two complete duplexers can be contained within the enclosure. The isolation provided by the Option 5 duplexers is approximately 15 to 20 dB.

To provide full band coverage, each duplexer is implemented in two frequency bands:

Band 1: 800 to 1300 MHz

Band 2: 1300 to 2500 MHz

6.10.1 Installing the Duplexer

To operate in the duplex mode, connect the MP-2500 *Channel 1 RF Input* and the *Channel 2 RF Output* to the appropriate SMA connectors on the duplexer. Ensure that the frequency bands of each connection are compatible. Connect the device under test to the type-N connector labeled *Channel 1 Duplex* of the appropriate frequency band (Figure 6-17).

A second duplexer may be required for special test situations. It should be connected to *Channel 2 RF Input* and *Channel 1 RF Output* for testing with two duplex devices.

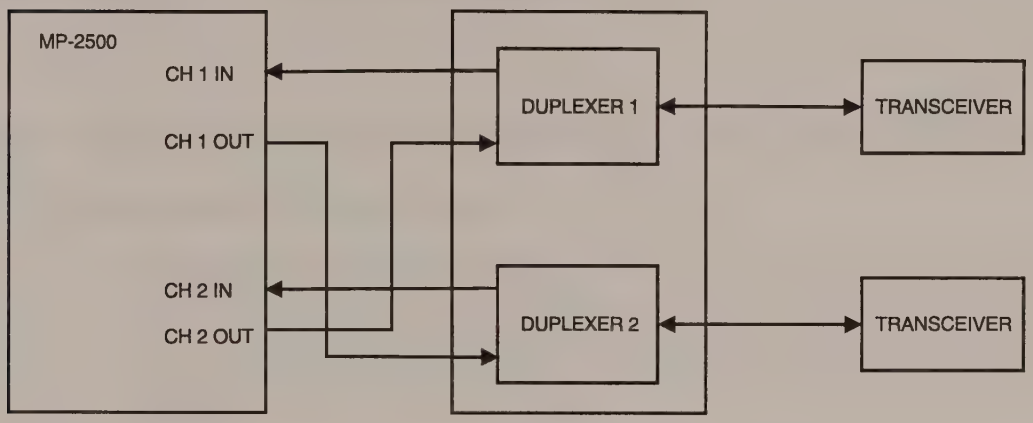


Figure 6-17. Connections for the Duplexer Option

6.10.2 Operating the Duplexer

Observe the following precautions when setting the operating power levels:

- Channel 1 of the MP2500 is used for the transmit band. The rated MP-2500 input power level of +20 dBm should not be exceeded. To accommodate higher test signal levels, place a high power attenuator between the Duplexer and the output of the device under test. In this configuration, there may be as much as +5 dBm leakage into the output of the other channel.

  This leakage will not degrade test accuracy if the frequency offset between the transmit and receive bands is 45 MHz or greater. If the frequency offset between the bands is less than 45 MHz, spurious responses may occur at the MP-2500 Channel 2 output.

- The power output level from Channel 2 of the MP-2500 should be set to less than -55 dBm to avoid creating spurious responses in the transmit band.

Section 7. Maintenance

7.1 Adjustments and Calibration

To maintain optimum measurement performance, the MP-2500 should be calibrated after one year of service and every two years thereafter. Because of the unique test configurations required for MP-2500 calibration, it is recommended that the MP-2500 be returned to Noise Com, Inc., for calibration. Calibration can usually be completed in one day.

7.2 Troubleshooting and Repair

The MP-2500 should only be serviced by Noise Com, Inc., service personnel or trained customer maintenance personnel using the Noise Com *Service Manual for the MP-2500 Multipath Emulator.*

For instruments requiring service, either in or out of warranty, contact the Noise Com, Inc., Customer Service Department at (201) 261-8797 for pricing and instructions before returning your MP-2500. When you call, be sure to have the following information available:

- Model number
- Serial number
- Full description of the failure condition
- Name and phone number of the technical contact at you facility

7.3 Equipment Returns

All instruments returned to Noise Com, Inc., for repair must be shipped prepaid. Instruments eligible for in-warranty repairs will be returned prepaid to the customer. For instruments that are out-of-warranty, or that have been mishandled, the customer will be responsible for return shipping charges. An evaluation fee will be charged for testing and processing units that are found to have no functional or performance defects.

For out-of-warranty instruments, Noise Com, Inc., will provide an estimate for the cost of repair. Customer approval of the charges will be required before repairs can be made. For units deemed to be beyond repair, or in situations in which the customer declines to authorize repair charges, handling charges may be assessed for the evaluation by Noise Com, Inc.

Appendix A. Definitions

Term	*Definition*
channel	The signal handling circuitry extending from a single RF input to the RF output. A channel may have from one to twelve paths, which simultaneously and in parallel, process the input signal. Two channels are available in the MP-2500 with Option 2. Each channel in the dual-channel instrument is independent and has from one to six paths.
correlation	A mutual relationship between two paths. When the correlation is set to 0%, the Rayleigh distributions of the paths are statistically independent of each other. When the correlation is set to 100%, the Rayleigh distribution of the paths is identical.
Doppler shift	A change in frequency due to a change in distance over time between the transmitter and receiver. The MP-2500 emulates Doppler by shifting the carrier frequency of the received signal. The relative velocity between the transmitter and receiver is calculated and displayed as speed in the User-selected units.
dynamic mode	One of two operating modes provided by the MP-2500 applications program. This mode simulates a receiver moving through an environment of up to eleven reflectors. The transmitter is stationary. A direct path is always present between the transmitter and receiver. The parameter settings of the 11 possible reflected paths are relative to the direct path. A Map View is provided, which depicts the physical location of the transmitter, receiver, reflectors, and the travel path of the receiver. The receiver follows a course which is defined by a minimum of two and a maximum of nine nodes. Each node is assigned a position and a speed. The receiver will move sequentially from node to node. The receiver will accelerate or decelerate linearly if adjacent nodes have non-equal velocities. Two consecutive velocities of zero will terminate the run.

Term	*Definition*
node	In the Dynamic operating mode of the MP-2500, refers to a point on the course along which a mobile receiver will travel. Each node is defined by a position and the receiver velocity. The number of nodes can be set from 2 to 9.
path	The course that a signal takes in order to arrive at the receiver from the transmitter. A direct path is one that is the shortest distance between the transmitter and receiver and involves no reflectors. In the Dynamic mode, the direct path is transparent to the User. It is always set to minimum signal loss and delay.
Rayleigh distribution	The summation of two orthogonal vectors, each of which has been multiplied by uncorrelated Gaussian distributions. The Rayleigh distribution is utilized in the MP-2500 to emulate the effect placed upon a reflected signal which has an equiprobable phase distribution over 0° to 360°, and a spectral density distribution which spreads the signal over a band of $\pm f_d$, the Doppler frequency.
reflector	An object which reflects an RF transmission, creating a signal path between the transmitter and receiver other than the direct path. In the Dynamic operating mode of the MP-2500, each reflector is assigned a position, Doppler frequency, loss value, and spectrum type. The loss value, which is relative to the direct path, is that of the reflector, only. The path length losses are computed by the MP-2500 and are transparent to the User. For each active reflector, a corresponding hardware path is enabled in the MP-2500.
segment	A term used in the Static operating mode of the MP-2500 which refers to one set of parameters. Up to 8 segments can be linked together and saved under a single file name. When the file is run, the segments are executed sequentially.

Term	*Definition*
static mode	One of two operating modes provided by the MP-2500. All parameter settings remain fixed as a file is running. The user must enter the desired parameters for each path (spectrum type, Doppler frequency, loss, delay, and correlation), as well as output attenuation, initial delay, center frequency, time duration, segment number, Doppler, and the number of runs. Path parameters can be modified while running without interrupting the file. Many files for running standard tests for CDMA, GSM, and DCS are prestored on the hard disk.

Appendix B. Warranty

B.1 Rights and Advises

Noise Com, Inc., reserves the right to make changes without notice in MP-2500 hardware or software and hardware/software specifications. Customers are advised to obtain the latest version of the MP-2500 specifications before placing an order to verify that the information relied upon is current.

Specifications contained in this publication supersede all data for the MP-2500 published by Noise Com, Inc., prior to September 1994.

B.2 Warranty and Assistance

All Noise Com, Inc., products are warranted against defects in material and workmanship for a period of one year from the date of shipment. Noise Com, Inc., will, at its option, repair or replace products that prove to be defective during the warranty period, provided they are returned to Noise Com, Inc., and provided the preventive maintenance procedures are followed. Repairs necessitated by misuse of the product are not covered by this warranty. No other warranties are expressed or implied, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. Noise Com, Inc., is not liable for consequential damages.

Service Manual

Model MP-2500
Multipath Fading Emulator

Rev 0
November, 1995

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Section 1. Overview

1.1 How to Use This Manual

The MP-2500 Service Manual is one of two manuals which make up the documentation for the MP-2500 Multipath Fading Emulator. This manual is intended to assist you in maintaining the MP-2500. The information in this manual is primarily of interest to maintenance technicians who are performing routine maintenance or troubleshooting suspected faults.

Section 1 "Overview" provides an introduction to the maintenance routines that will ensure optimum performance and enhance instrument lifetime.

Section 2 "Equipment Specifications" provides a baseline for performance measurements.

Section 3 "Operations Verification" presents procedures for verifying the functional performance of the MP-2500.

Section 4 "Performance Verification" presents procedures for verifying performance levels.

Section 5 "Adjustments" presents procedures for adjusting the output level and carrier suppression.

Section 6 "Troubleshooting and Repair" is a guide for troubleshooting and repairing suspected instrument faults.

1.2 Maintenance Categories

Maintenance of the MP-2500 is categorized into routine maintenance, troubleshooting, and repair. Troubleshooting and repair procedures are presented in Section 6. Routine maintenance intervals and procedures are presented in the remainder of this section.

1.3 Routine Maintenance

1.3.1 Maintenance Intervals

To optimize the performance of the MP-2500 and prolong its operating lifetime, perform the recommended routine maintenance procedures at the intervals indicated in Table 1-1.

Table 1-1: Routine Maintenance Intervals

Item	Operation	Interval			Comments
		Initial Install.	After Move	Annually	
1	Visual inspection	✔	✔	✔	Procedure listed in para. 1.3.2
2	Calibration	✔	✔	✔	Procedure listed in para. 1.3.3
3	Operational verification	✔			Also perform when a fault is suspected
4	Performance verification			✔	Part of annual calibration
5	Adjustments			✔	Part of annual calibration
6	Cleaning			✔	Procedure listed in para. 1.3.4

1.3.2 Visual Inspection

Visually inspect the MP-2500 as follows:

1. Inspect the power cord, mouse ball, mouse cord, and keyboard cord.
2. Check all RF connectors for damaged threads, foreign material on the mating surfaces, and tightness (on the front panel).
3. Check chassis hardware for tightness.

1.3.3 Calibration

Calibration of the MP-2500 is accomplished by preforming the procedures listed in Sections 3 and 4.

1.3.4 Cleaning

WARNING Disconnect power before opening the MP-2500 case.

1. Remove two screws, one on each side, from the rear bezel.
2. Slide the bezel toward the rear. It will separate from the instrument.

3. Lift the top cover.
4. Pick up the rear of the instrument by the rear panel and slide the bottom cover out.
5. Remove the black filter material from the inside of the bottom cover.
6. Clean any dust and dirt buildup on the filter by gently brushing it.
7. Reapply the filter material to the bottom cover, aligning it to cover all the air slots.
8. Remove and clean the filter material which is located on the inside of the front panel near the bottom.
9. Reapply the filter material, aligning it to cover all the air slots.
10. Replace the top and bottom covers, ensuring that the front and side edges of the covers are fully inserted into the mating slots on the frame.
11. Replace the rear bezel by pressing it onto the rear edges of both covers and in contact with the mating frame along both sides.
12. Ensure that the bezel is fully engaged around its entire perimeter.
13. Reinsert and tighten the two retaining screws while compressing the front and rear bezels onto the covers.
14. To verify proper bezel installation, gently apply pressure to move the top and bottom covers. They should be firmly seated and not move.

Section 2. Specifications

The performance specifications, physical dimensions, and power requirements for the MP-2500 are listed in Table 2-1.

Table 2-1: MP-2500 Specifications

Frequency range	
Baseline	800 to 2500 MHz
Option	DC to 6000 MHz, in multiple bands
RF input power range	
Baseline	-10 to + 20 dBm, with 54 dB SNR Usable to -64 dBm
Option	+13 dBm to + 43 dBm, with 54 dB SNR
RF output power range	
Baseline	-19 to -100 dBm
Option	0 to -80 dBm
Number of paths (user programmable)	Up to 12 (MP-2500-12)
RF Bandwidth (3 dB)	6.0 MHz, typical
Attenuation accuracy	±0.2 dB
Amplitude ripple	±0.2 dB from best-fit straight line
Path attenuation range	0 to 30 dB
Path attenuation resolution	0.017 dB
Path-path amplitude balance	±0.2 dB, maximum
Path on/off ratio	65 dB, minimum
S/N ratio at output > -34 dBm	54 dB per 6 MHz bandwidth
Spurious output	-55 dBc or -85 dBm, whichever is greater
Path-to-path delay range	0 to 216 µs
Delay resolution	1 ns
Path-to-path delay accuracy	±5 ns, maximum

Table 2-1. MP-2500 Specifications *(continued)*

Group delay variation	±30 ns, typical	
Residual channel delay	2.6 µs, typical	
Doppler range		
Baseline	0 to ±780 Hz	
Option	0 to ±1560 Hz (1 to 3 paths, only)	
Doppler resolution	0.0156%	
Rayleigh distribution		
Repetition interval (programmable)	From 1 second to 24 hours, minimum	
Deviation from CPDF	±0.5 dB, maximum, from -25 to +10 dB	
Level crossing rate accuracy	±2.5%	
Path-to-path correlation	0 to 100%	
Correlation resolution	1%	
LO input frequency range	RF frequency plus 140 MHz	
LO input level	+13 dBm, nominal	
LO feedthrough on RF output	-75 dBm, typical	
Image feedthrough on RF output	-60 dBc, maximum	
Internal processor and peripherals		
486DX/33 MHz	4 MB RAM	Mouse
VGA display	88-key keyboard	Serial port
3.5" floppy drive	420 MB hard drive	
IEEE-488.2 interface	Parallel/printer port	
RF input/output connectors	50 ohms SMA female	
Input VSWR	1.8:1, maximum	
Output VSWR	1.5:1, maximum	
Primary power		
Voltage	90 - 264 VAC, autoranging	
Frequency	48 - 66 Hz	
Consumption	300 VA, maximum	
Fuse	4 A, slow-blow	
Operating temperature range	0°to 50°C	

Table 2-1. MP-2500 Specifications *(continued)*

Instrument safety	UL-1244, CSA 231, IEC-1010-1
EMC	EN55011, Group 1, Class A
Dimensions	455 mm D x 364 mm W x 197 mm H (17.9 in D x 14.3 in W x 7.8 in H)

Specifications for Option 4: High Power Attenuator

Frequency range	DC to 8 GHz
Nominal attenuation	20 ±0.3 dB
Maximum VSWR	1.20:1 into 50 ohms
Power rating	25 watts average to 25°C derated to 2.5 watts @ 125°C 5 KW peak, 5 µsec pulse, 0.25% duty cycle
Temperature coefficient	0.0004 dB/dB/°C
Power coefficient	0.0006 dB/dB/watt
Connectors	Type N female
Weight	170 grams
Physical dimensions	See Figure 2-1.

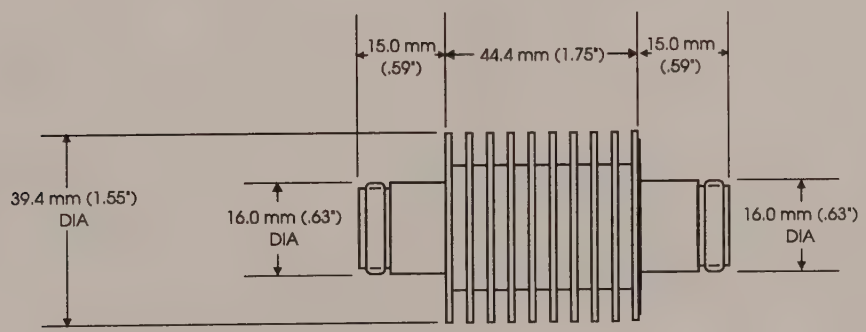


Figure 2-1. High Power Attenuator

Table 2-1. MP-2500 Specifications *(continued)*

Specifications for Option 5: Duplexer

Channels	Two independent duplex channels. Each channels supports two frequency bands.
Frequency range	800 to 1300 MHz 1300 to 2500 MHz
Isolation	
Minimum	15 dB
Typical	20 dB
Insertion loss	1 dB, maximum
Maximum VSWR	1.5:1
Connectors	
Duplex ports	Type N female
Uni-directional ports	SMA female
Dimensions	368.0 mm W x 120.6 mm H x 425.5 mm D (14.5" W x 4.75" H x 16.75" D)

Specifications for Option 8: Synthesized Local Oscillator

Frequency range	960 MHz to 2640 MHz
Frequency resolution	1 MHz
Phase jitter	<1°RMS, 10 Hz to 100kHz, single sideband
Output Power	+10 dBm, minimum
Power at Sample output	-20 dBm, typical
Spurious outputs	-60 dBc @ $F_C \pm 10$MHz
Harmonics	-10 dBc, maximum
Power consumption	250 watts per synthesizer
Input line voltage	Selectable from 100 VAC to 240 VAC, 50-60 Hz
Dimensions	368.0 mm W x 120.6 mm H x 425.5 mm D (14.5" W x 4.75" H x 16.75" D)

Section 3. Operations Verification

3.1 General

This section provides procedures for verifying the operation of the MP-2500. See Section 4 for performance verification procedures, Section 5 for adjustment procedures, and Section 6 for a troubleshooting guide.

3.2 Test Equipment

Table 3-1 lists the test equipment recommended for verifying the operation of the MP-2500.

Table 3-1: Test Equipment Recommended for Verifying Operation

Item	Description	Features	Manufacturer	Model
1	Spectrum analyzer	10 MHz to 3 GHz	Hewlett Packard	8566B
2	Synthesized signal generator	800 MHz to 2500 MHz; external pulse input; -20 dBm to +20 dBm	Hewlett Packard	8341B
3	Synthesized signal generator	940 MHz to 2640 MHz; +13 dBm	Hewlett Packard	8341B
4	RF frequency counter	800 MHz to 2500 MHz	Hewlett Packard	5350B
5	Power meter/power sensor	800 MHz to 2500 MHz; -60 dBm to -29 dBm	Hewlett Packard	436A/ 8484A
6	RF Amplifier	30 dB gain @ 800 MHz; 0 dBm output into 50 ohms		
7	Computer	PCIIA controller card and National Instruments interactive debug program (IBIC); 8 MB RAM; 10 MB available on the hard drive.	IBM-compatible	

3.3 Operations Test Procedures

The remainder of this section consists of the MP-2500 operation verification test procedures. Each procedure includes blank spaces for you to use to indicate the successful completion of the steps and record test data. Because you may wish to repeat some of these verification tests after updating the MP-2500 software or after the MP-2500 has been transported, stored, or maintained, ***you are strongly advised*** to photocopy the procedure pages and record all test results on the copies.

3.3.1 Turn-On

Purpose	To verify that the computer, computer peripherals, and operating system are functioning properly.
Test Equipment	None
Setup	Connect the MP-2500 according to the instructions provided in the *Technical Manual for the MP-2500 Multipath Fading Emulator*, Section 2.
Procedure	❒ 1. Turn on the MP-2500 and verify that the VGA display is visible. ❒ 2. Optimize the contrast using the *Display Contrast* adjustment screw on the front panel. ❒ 3. Verify that the mouse is operating by moving the cursor to the *OPEN STATIC FILE* button on the Main Display. ❒ 4. Click the left mouse button on the *OPEN STATIC FILE* button. ❒ 5. Click[a] on the down arrow button located to the right of the *File Name* dialog box to scroll down the list of files. Select the file named *checkit.sta* and click the *OK* button. The *Static Parameter View* will appear. ❒ 6. Verify that the keyboard is functioning by pressing the *TAB* key three times to move the cursor to the *Description* box. Type in a suitable description and press *Enter*. ❒ 7. Proceed to the next test or select *File, Exit* to halt the program.

a. Unless otherwise instructed, always click with the left mouse button.

Tester:	Title:	Date:

3.3.2 Output Power at 800 MHz

Purpose

To verify that an output signal is present and is at the correct power level.

Test Equipment

Spectrum analyzer:	HP Model 8566B, or equivalent. 10 MHz to 3 GHz
RF signal generator:	HP Model 8341B, or equivalent. 800 to 2500 MHz
LO signal generator:	HP Model 8341B, or equivalent. 940 to 2640 MHz
Power Meter:	HP Model 436A, or equivalent, 800 MHz, -30 dBm

Setup

Connect the RF signal generator, the LO signal generator, the spectrum analyzer, the power meter and the MP-2500 as shown in Figure 3-1. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	0 dBm	+13 dBm
Modulation	none	none

	Spectrum Analyzer
Center frequency	800 MHz
Span	10 MHz
Reference level	-25 dBm

Procedure

- ❒ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*
- ❒ 2. Press *Start* (or *F3*) on the MP-2500 display.
- ❒ 3. Observe the signal on the spectrum analyzer. It should be at 800 MHz with a power level of approximately -30 dBm.
- ❒ 4. Disconnect the spectrum analyzer and connect the power sensor directly to the RF output connector on the MP-2500.
- ❒ 5. Measure and record the MP-2500 output power. _____ dBm

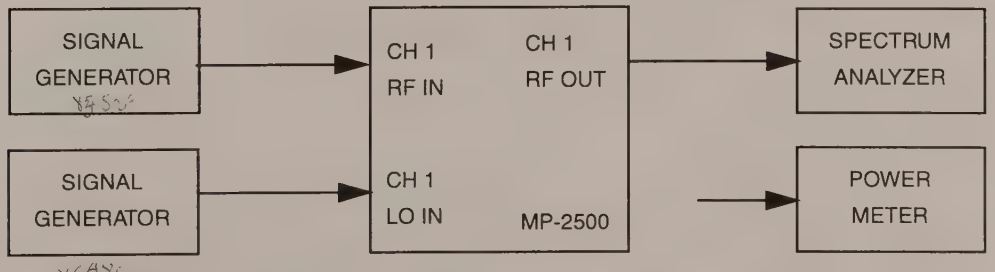


Figure 3-1. Basic Measurement Setup

Tester:	Title:	Date:

3.3.3 Input Power Range

Purpose

To verify that the AGC operates properly over the specified input power range.

Test Equipment

Spectrum analyzer: HP Model 8566B, or equivalent. 10 MHz to 3 GHz
RF signal generator: HP Model 8341B, or equivalent. 800 to 2500 MHz
LO signal generator: HP Model 8341B, or equivalent. 940 to 2640 MHz

Setup

Connect the RF signal generator, the LO signal generator, the spectrum analyzer, and the MP-2500 as illustrated in Figure 3-1. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	0 dBm	+13 dBm
Modulation	none	none

	Spectrum Analyzer
Center frequency	800 MHz
Span	10 MHz
Reference level	-25 dBm

Procedure

❒ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*

❒ 2. Press *Start* (or *F3*) on the MP-2500 display.

❒ 3. Use the marker function on the spectrum analyzer to mark the peak amplitude on the analyzer display.

❒ 4. Observing the MP-2500 output power level, slowly increase the RF signal generator power output to +20 dBm. Record the maximum MP-2500 output power level. _____dBm

❒ 5. Slowly decrease the RF signal generator output to -10 dBm. Record the minimum MP-2500 output power level. _____dBm

❒ 6. If operating properly, the MP-2500 output power should have remained constant to within 1 dB. ok.

Tester:	Title:	Date:

3.3.4 Input Power with AGC Off

Purpose

To verify that the AGC On/Off control is operating properly.

Test Equipment

Spectrum analyzer: HP Model 8566B, or equivalent. 10 MHz to 3 GHz
RF signal generator: HP Model 8341B, or equivalent. 800 to 2500 MHz
LO signal generator: HP Model 8341B, or equivalent. 940 to 2640 MHz

Setup

Connect the RF signal generator, the LO signal generator, the spectrum analyzer, and the MP-2500 as illustrated in Figure 3-1. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	-15 dBm	+13 dBm
Modulation	none	none

	Spectrum Analyzer
Center frequency	800 MHz
Span	10 MHz
Reference level	-25 dBm

Procedure

- ❒ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*
- ❒ 2. Press *Reset* (or *F2*) on the MP-2500 display.
- ❒ 3. Select *Options, Set AGC* to activate the *Change AGC* dialog box.
- ❒ 4. Select *Off* and press the *OK* button.
- ❒ 5. Press *Start* (or *F3*). The output signal should appear on the spectrum analyzer.
- ❒ 6. Increase the input signal power (RF SIGNAL GEN ✓) until spurious sidebands appear in the spectrum. This is the saturation point of the MP-2500 with the AGC disabled.
- ❒ 7. Record the MP-2500 input power at saturation. -31.12 dBm
- ❒ 8. Reset AGC to *On*.

Tester:	Title:	Date:

3.3.5 Pulsed Signal Capability

Purpose

To verify that the MP-2500 can accommodate pulsed signals.

Test Equipment

Spectrum analyzer: HP Model 8566B, or equivalent. 10 MHz to 3 GHz
RF signal generator: HP Model 8341B, or equivalent. 800 to 2500 MHz
LO signal generator: HP Model 8341B, or equivalent. 940 to 2640 MHz

Setup

Connect the RF signal generator, the LO signal generator, the spectrum analyzer, and the MP-2500 as illustrated in Figure 3-1. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	0 dBm	+13 dBm
Modulation	40 µsec pulse, 200 Hz repetition rate	none

	Spectrum Analyzer
Center frequency	800 MHz
Span	0 MHz (time domain display)
Reference level	-25 dBm
Vertical scale	5 dB/div
Sweep speed	20 µsec/div
Resolution BW	3 MHz
Trigger	video ADJ video TRIGGER LEVEL.

Procedure

- ❒ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*
- ❒ 2. Press *Start* (or *F3*) on the MP-2500 display. The detected amplitude envelope will appear.
- ❒ 3. Verify that the peak pulse amplitude is within 1 dB of the CW amplitude that was measured in Test 3.3.2 *Output Power at 800 MHz.*
- ❒ 4. Verify that the droop across the pulsewidth is less than 0.5 dB.

Tester:	Title:	Date:

3.3.6 Output Power

Purpose

To verify the accuracy of output power settings.

Test Equipment

Spectrum analyzer: HP Model 8566B, or equivalent. 10 MHz to 3 GHz
RF signal generator: HP Model 8341B, or equivalent. 800 to 2500 MHz
LO signal generator: HP Model 8341B, or equivalent. 940 to 2640 MHz

Setup

Connect the RF signal generator, the LO signal generator, the spectrum analyzer, and the MP-2500 as illustrated in Figure 3-1. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	0 dBm	+13 dBm
Modulation	none	none

Spectrum Analyzer

Center frequency	800 MHz	Vertical Scale	10 dB/div
Span	10 MHz	Sweep speed	Auto
Reference level	-25 dBm	Resolution BW	Auto
Marker mode	Delta	Trigger	Free run

Procedure

- ❒ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*
- ❒ 2. Press *Start* (or *F3*) on the MP-2500 display.
- ❒ 3. Use the marker function on the spectrum analyzer to mark the peak amplitude on the analyzer display.
- ❒ 4. Press the left arrow key on the MP-2500 *Output Attn* slidebar to increment the output RF attenuation by 0.5 dB. Verify that the resulting marker delta on the spectrum analyzer is nominally 0.5 dB.
- ❒ 5. Repeat Step 4 for the 1, 2, 4, 8, and 32 dB steps of the MP-2500 *Output Power* control.

Tester:	Title:	Date:

3.3.7 Spurious Emissions

Purpose

To verify the spurious emission levels at the MP-2500 output.

Test Equipment

Spectrum analyzer: HP Model 8566B, or equivalent. 10 MHz to 3 GHz
RF signal generator: HP Model 8341B, or equivalent. 800 to 2500 MHz
LO signal generator: HP Model 8341B, or equivalent. 940 to 2640 MHz

Setup

Connect the RF signal generator, the LO signal generator, the spectrum analyzer, and the MP-2500 as illustrated in Figure 3-1. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	0 dBm	+13 dBm
Modulation	none	none

	Spectrum Analyzer
Center frequency	800 MHz
Span	400 MHz
Reference level	-20 dBm
Resolution BW	10 kHz

Procedure

❒ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*

❒ 2. In the *Path Parameter* table, double click on Path 2. Use the *Change Path 2 Parameter* box to select the *Doppler* spectrum type and to set *Speed* = 0 km/hr (if necessary). Press *OK*.

❒ 3. In the *Path Parameter* table, double click on Path 3. Use the *Change Path 3 Parameter* box to select the *Doppler* spectrum type and to set *Speed* = 0 km/hr (if necessary). Press *OK*.

❒ 4. Press *Start* (or *F3*) on the MP-2500 display.

❒ 5. Note any spurious signals on the spectrum analyzer display. Compare the signal spectrum to the typical display illustrated in Figure 3-2a.

❒ 6. Set the spectrum analyzer span to 10 MHz. Note any spurious signals on the analyzer display. Compare the signal spectrum to the typical display illustrated in Figure 3-2b.

(continued on next page)

Tester:	Title:	Date:

(continuation of 3.3.7 Spurious Emissions)

❒ 7. Set the spectrum analyzer span to 100 kHz. Set the *Resolution BW* to *Auto*. Note any spurious signals on the display. Compare the signal spectrum to Figure 3-2c.

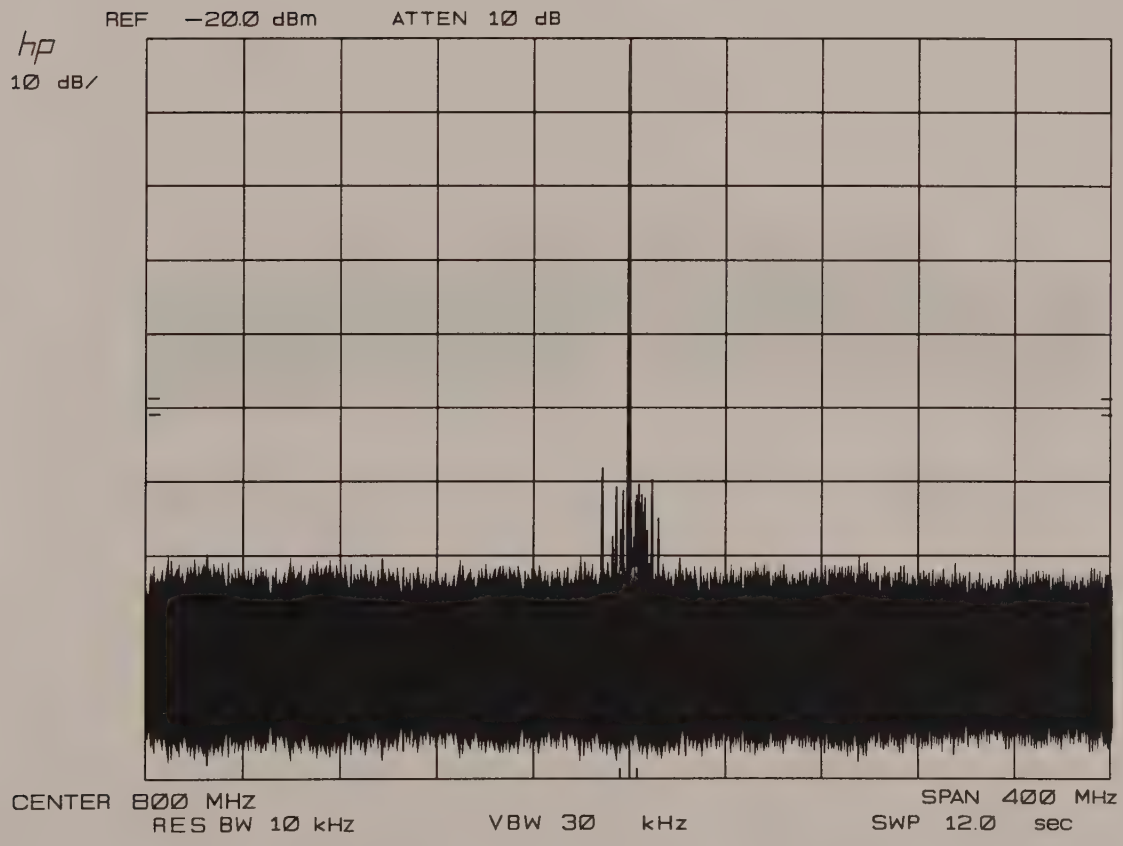


Figure 3-2a. Spectrum Analyzer Display (Span = 400 MHz)

Tester:	Title:	Date:

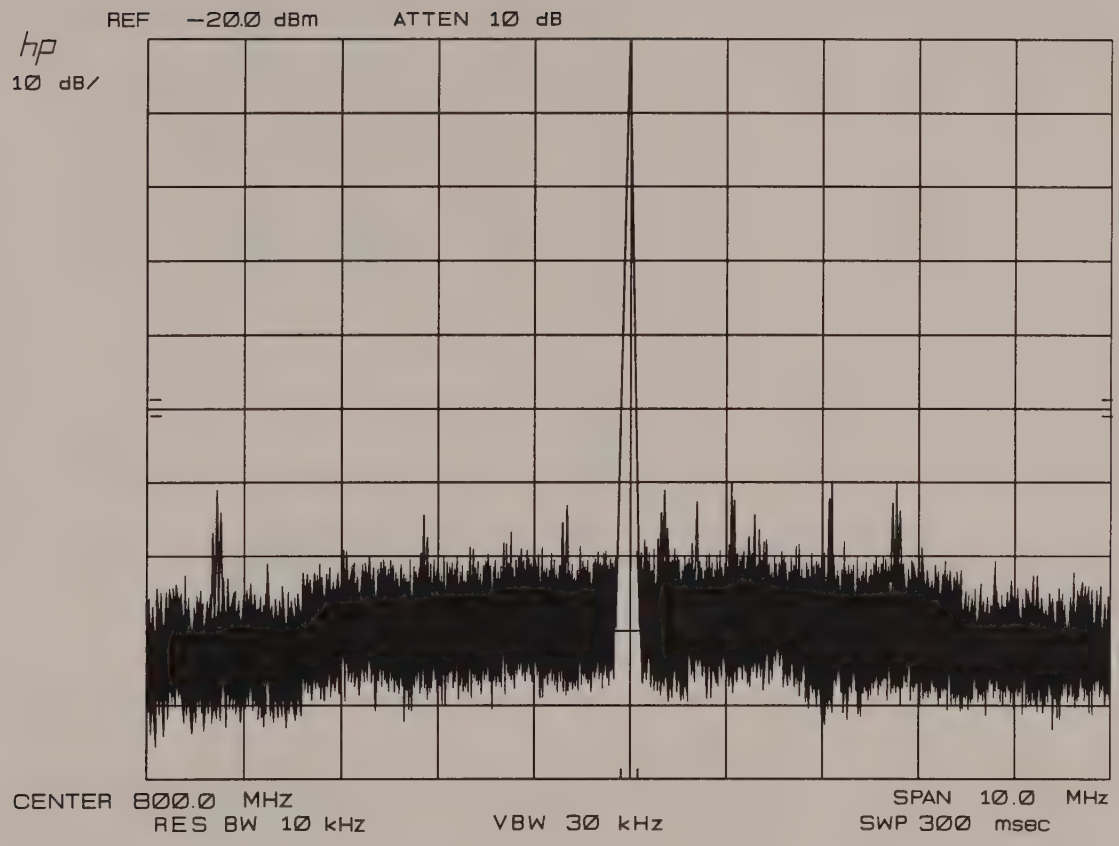


Figure 3-2b. Spectrum Analyzer Display (Span = 10 MHz)

Tester:	Title:	Date:

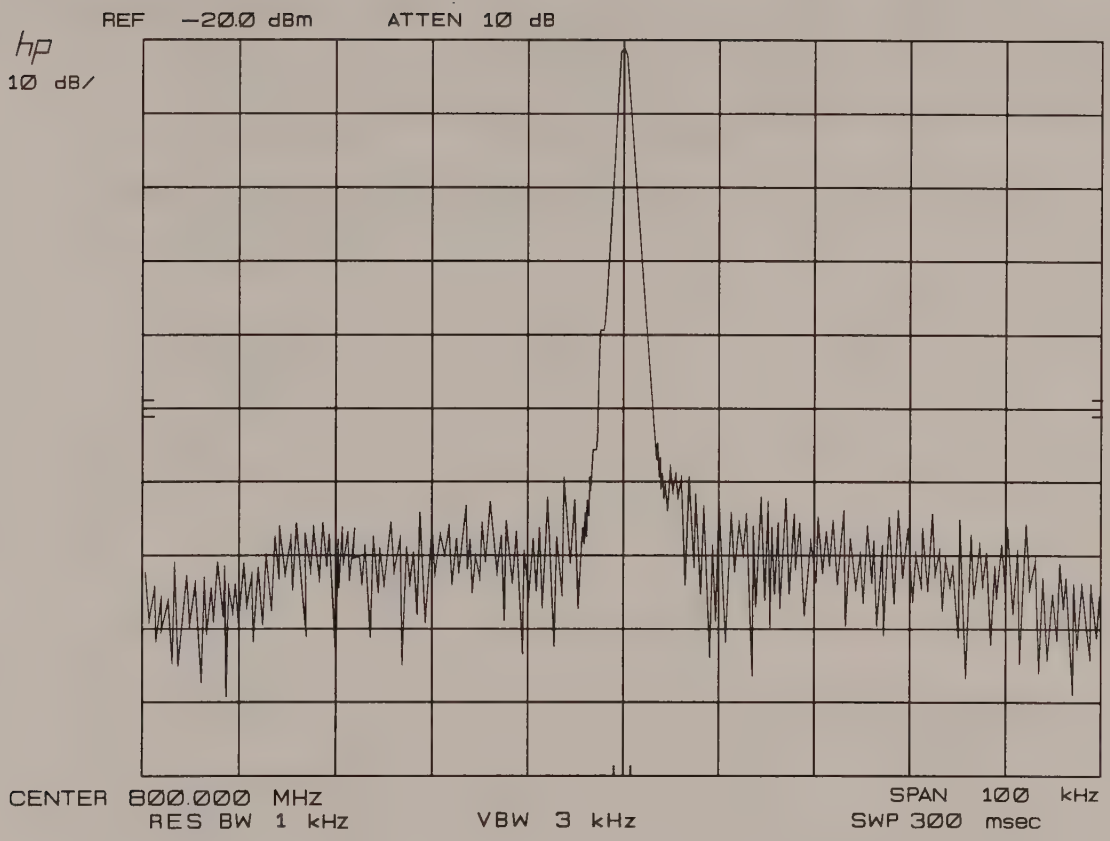


Figure 3-2c. Spectrum Analyzer Display (Span = 100 kHz)

Tester:	Title:	Date:

3.3.8 Path Parameters

3.3.8.1 Path Doppler

Purpose	To verify that the path Doppler complies with specifications.
Test Equipment	Frequency counter: HP Model 5350B, or equivalent. 800 MHz to 2500 MHz, 1 Hz resolution RF signal generator: HP Model 8341B, or equivalent. 800 to 2500 MHz LO signal generator: HP Model 8341B, or equivalent. 940 to 2640 MHz RF amplifier 30 dB gain @ 800 MHz
Setup	Connect the RF signal generator, the LO signal generator, the frequency counter, and the MP-2500 as shown in Figure 3-3. Set the instrument controls as follows: *RF Signal Generator* / *LO Signal Generator* Frequency: 800 MHz / 940 MHz Power: 0 dBm / +13 dBm Modulation: none / none
Procedure	☐ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.* ☐ 2. Press *Start* (or *F3*) on the MP-2500 display. ☐ 3. Record the frequency of the MP-2500 output. _____ MHz. ☐ 4. Set the Path 1 speed to 10 Km/hr. ☐ 5. Record the change in the MP-2500 output frequency (change from Step 3. _____ Hz. (Spec = 7.41 ±0.5 Hz) ☐ 6. Set the Path 1 speed to 1050 Km/hr. ☐ 7. Record the change in the MP-2500 output frequency (change from Step 3. _____Hz. (Spec = 778.3 ±0.5 Hz)

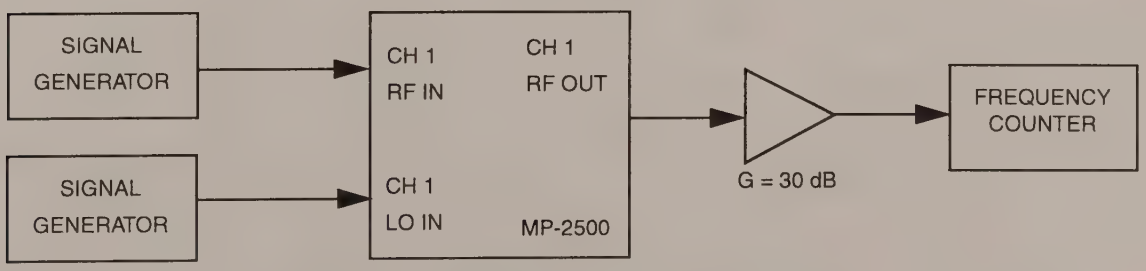


Figure 3-3. Doppler Measurement Setup

Tester:	Title:	Date:

3.3.8.2 Path Loss

Purpose

To verify that the path loss complies with specifications.

Test Equipment

RF signal generator:	HP Model 8341B, or equivalent. 800 to 2500 MHz
LO signal generator:	HP Model 8341B, or equivalent. 940 to 2640 MHz
Power meter:	HP Model 436A, or equivalent. 10 MHz to 3 GHz
Power head:	HP Model 8484A, or equivalent. 10 MHz to 18 GHz, -20 to -70 dBm.

Setup

Connect the RF signal generator, the LO signal generator, the spectrum analyzer, and the MP-2500 as illustrated in Figure 3-1. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	0 dBm	+13 dBm
Modulation	none	none

Procedure

❒ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*

❒ 2. Connect the power meter to the MP-2500 *Ch 1 RF OUT* connector.

❒ 3. Press *Start* (or *F3*) on the MP-2500 display.

❒ 4. Set the power meter to the *dB (Ref)* mode.

❒ 5. Change the MP-2500 path loss setting to the following values and record the signal level changes indicated by the power meter:

Path Loss Setting	Actual Decrease in Power	Specification
0.1 dB	_____ dB	0.1 ±0.05 dB
0.5 dB	_____ dB	0.5 ±0.05 dB
2.0 dB	_____ dB	2.0 ±0.05 dB
10.0 dB	_____ dB	10.0 ±0.2 dB
20.0 dB	_____ dB	20.0 ±0.5 dB
30.0 dB	_____ dB	30.0 ±1.0 dB

Tester:	Title:	Date:

3.3.8.3 Path Delay

Purpose

To verify that the path delay complies with specifications.

Test Equipment

Spectrum analyzer:	HP Model 8566B, or equivalent. 10 MHz to 3 GHz
RF signal generator:	HP Model 8341B, or equivalent. 800 to 2500 MHz
LO signal generator:	HP Model 8341B, or equivalent. 940 to 2640 MHz

Setup

Connect the RF signal generator, the LO signal generator, the spectrum analyzer, and the MP-2500 as illustrated in Figure 3-1. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	0 dBm	+13 dBm
Modulation	40 µsec pulse, 200 Hz repetition rate	none

	Spectrum Analyzer
Center frequency	800 MHz
Span	0 MHz
Reference level	-25 dBm
Vertical scale	5 dB/div
Sweep speed	20 µsec/div
Resolution BW	3 MHz
Trigger	video ADJ VideoTRigger Level

Procedure

- ❒ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*
- ❒ 2. Press *Start* (or *F3*) on the MP-2500 display.
- ❒ 3. In the *Path Parameter* table, double click on Path 2. Use the *Change Path 2 Parameters* box to select the *Doppler* spectrum type and to set *Speed* = 0 km/hr (if necessary). Press *OK*.
- ❒ 4. Observe the pulse envelope on the spectrum analyzer.
- ❒ 5. Use the *Change Path 2 Parameters* box to set the *Delay* in Path 2 to 10 µsec.
- ❒ 6. Observe a change in output level after the first 10 µsec of the output pulse (which occurs because only Path 1 is present for the first 10 µsec of the pulse interval.)

  Note that the output level may either increase or decrease, depending on the phase relationship between the Path 1 and Path 2 signals.

Tester:	Title:	Date:

3.3.8.4 Path Phase Shift

Purpose

To verify that the phase shift complies with specifications.

Test Equipment

Spectrum analyzer:	HP Model 8566B, or equivalent. 10 MHz to 3 GHz
RF signal generator:	HP Model 8341B, or equivalent. 800 to 2500 MHz
LO signal generator:	HP Model 8341B, or equivalent. 940 to 2640 MHz

Setup

Connect the RF signal generator, the LO signal generator, the spectrum analyzer, and the MP-2500 as illustrated in Figure 3-1. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	0 dBm	+13 dBm
Modulation	none	none

Spectrum Analyzer

Center frequency	800 MHz	Resolution BW	Auto
Span	1 MHz	Sweep speed	Auto
Reference level	-25 dBm	Trigger	Free run
Vertical Scale	10 dB/div		

Procedure

- ❒ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*
- ❒ 2. Press *Start* (or *F3*) on the MP-2500 display.
- ❒ 3. Use the marker function on the spectrum analyzer to mark the peak amplitude on the analyzer display.
- ❒ 4. In the *Path Parameter* table, double click on Path 2. Use the *Change Path 2 Parameters* box to select the *Doppler* spectrum type and to set *Phase Offset* to 180°. Press *OK*.
- ❒ 5. Press *Reset* (or *F2*) followed by *Start* (or *F3*) to correlate Paths 1 and 2.
- ❒ 6. Observe a 10 dB (or greater) decrease in the output amplitude (which results from the summation of two vectors which are 180° out of phase).

Tester:	Title:	Date:

3.3.9 Testing the Remaining Paths in Channel 1

Repeat Path Parameter Tests 3.3.8.1 through 3.3.8.4 for each of the untested paths in Channel 1.

3.3.10 Testing Channel 2

Repeat the previous test sequence (Tests 3.3.1 through 3.3.9) for Channel 2.

- get out.
- then go back checkit.sta
- view chan 2

Tester:	Title:	Date:

3.3.11 Configurations

3.3.11.1 Diversity

Purpose

To verify that the internal diversity signal routing is functioning properly.

Test Equipment

Spectrum analyzer: HP Model 8566B, or equivalent. 10 MHz to 3 GHz
RF signal generator: HP Model 8341B, or equivalent. 800 to 2500 MHz
LO signal generator: HP Model 8341B, or equivalent. 940 to 2640 MHz

Setup

Connect the RF signal generator, the LO signal generator, the spectrum analyzer, and the MP-2500 as illustrated in Figure 3-1. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	0 dBm	+13 dBm
Modulation	none	none

	Spectrum Analyzer
Center frequency	800 MHz
Span	10 MHz
Reference level	-25 dBm

Procedure

- ❒ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*
- ❒ 2. Select *Configuration, Diversity.*
- ❒ 3. Press *Start* (or *F3*) on the MP-2500 display.
- ❒ 4. Observe that the Channel 1 output is present on the spectrum analyzer at a center frequency of 800 MHz and a power level of approximately -30 dBm.
- ❒ 5. Connect the spectrum analyzer to the Channel 2 output.
- ❒ 6. Select *View, Channel 2.*
- ❒ 7. Press *Start* (or *F3*) on the MP-2500 display.
- ❒ 8. Verify that the 800 MHz signal is present at approximately -30 dBm.

Tester:	Title:	Date:

3.3.11.2 Interference

Purpose

To verify that the internal interference signal routing is functioning properly.

Test Equipment

Spectrum analyzer: HP Model 8566B, or equivalent. 10 MHz to 3 GHz
RF signal generator: HP Model 8341B, or equivalent. 800 to 2500 MHz
LO signal generator: HP Model 8341B, or equivalent. 940 to 2640 MHz

Setup

Connect the RF signal generator, the LO signal generator, the spectrum analyzer, and the MP-2500 as illustrated in Figure 3-1. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	0 dBm	+13 dBm
Modulation	none	none

	Spectrum Analyzer
Center frequency	800 MHz
Span	10 MHz
Reference level	-25 dBm

Procedure

- ❒ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*
- ❒ 2. Select *Configuration, Interference.*
- ❒ 3. Press *Start* (or *F3*) on the MP2500 display.
- ❒ 4. Observe that the Channel 1 output is present on the spectrum analyzer at a center frequency of 800 MHz and a power level of approximately -30 dBm.
- ❒ 5. Connect the RF signal generator to the Channel 2 RF input.
- ❒ 6. Select *View, Channel 2.*
- ❒ 7. Press *Start* (or *F3*) on the MP-2500 display.
- ❒ 8. Verify that the 800 MHz signal is present at the Channel 1 output at approximately -30 dBm.

Tester:	Title:	Date:

3.3.12 Remote IEEE-488 Interface

Purpose

To verify that:

1. the IEEE-488 Interface is functioning as a bus listener
2. the front panel remote LED indicator is functioning properly

Test Equipment

IBM-compatible PC equipped with an IEEE-488 controller.

Setup

Connect a control cable between the controller card in the PC and the appropriate connector on the rear of the MP-2500.

Procedure

1. Input the following to the PC:

	Input	Response
❒	`IBIC`	Loads the *IBIC* program.
❒	`Set 488.2`	Instructs the program to use IEEE routines.
❒	`SENDIFC`	Clears the IEEE interface.
❒	`Send 1 "OPEN checkit.sta" nlend`	The MP-2500 loads the *checkit.sta* file. The front panel *Remote* LED indicator turns on.

Tester:	Title:	Date:

Section 4. Performance Verification

4.1 General

This section provides procedures for verifying the performance of the MP-2500. See Section 3 for operation verification procedures, Section 5 for adjustment procedures, and Section 6 for a troubleshooting guide.

4.2 Test Equipment for Performance Tests

Table 4-1 lists the test equipment recommended for verifying the performance of the MP-2500.

Table 4-1: Test Equipment Recommended for Verifying Performance

Item	Description	Features	Manufacturer	Model
1	Spectrum analyzer	10 MHz to 3 GHz	Hewlett Packard	8566B
2	Synthesized signal generator	800 MHz to 2500 MHz; external AM input; -20 dBm to +20 dBm	Hewlett Packard	8341B
3	Synthesized signal generator	940 MHz to 2640 MHz; +13 dBm	Hewlett Packard	8341B
4	RF frequency counter	800 MHz to 2500 MHz	Hewlett Packard	5350B
5	Vector network analyzer	800 MHz to 2500 MHz	Hewlett Packard	8753D
6	Power meter/power sensor	800 MHz to 2500 MHz; -60 dBm to -29 dBm	Hewlett Packard	436A/ 8484A
7	Plotter	IEEE interface	Hewlett Packard	7470A
8	Computer	PCIIA controller card and National Instruments interactive debug program (IBIC); 8 MB RAM; 10 MB available on the hard drive.	IBM compatible	

4.3 Performance Test Procedures

The remainder of this section consists of the MP-2500 performance verification test procedures. Each procedure includes blank spaces for you to use to indicate the successful completion of the steps and record test data. Because you may wish to repeat some of these verification tests after updating the MP-2500 software or after the MP-2500 has been transported, stored, or maintained, ***you are strongly advised*** to photocopy the procedure pages and record all test results on the copies.

4.3.1 Output Power as a Function of Frequency

Purpose

To verify the insertion loss over the operating frequency range.

Test Equipment

Spectrum analyzer: HP Model 8566B, or equivalent. 10 MHz to 3 GHz
RF signal generator: HP Model 8341B, or equivalent. 800 to 2500 MHz
LO signal generator: HP Model 8341B, or equivalent. 940 to 2640 MHz

Setup

Connect the RF signal generator, the LO signal generator, the spectrum analyzer, and the MP-2500 as illustrated in Figure 3-1. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	0 dBm	+13 dBm
Modulation	none	none
Step Size	20 MHz	20 MHz

	Spectrum Analyzer
Center frequency	800 MHz to 2500 MHz
Reference level	-28 dBm
Vertical scale	1 dB/div
Resolution BW	Auto

Procedure

- ❒ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*
- ❒ 2. Press *Start* (or *F3*) on the MP-2500 display.
- ❒ 3. Place the spectrum analyzer in the *Max Hold* mode.
- ❒ 4. Simultaneously step the two signal generators and the MP-2500 from 800 MHz to 2500 MHz (940 MHz to 2640 MHz for the LO signal generator).

  [To change the MP-2500 frequency, press *Reset* (or *F2*); modify the center frequency; and press *Start* (or *F3*).]
- ❒ 5. Use the spectrum analyzer to observe the signal amplitude variation across the operating frequency band. ≈ _____ dB

  The peak-to-peak variation should be less than 6 dB. ✓

Tester:	Title:	Date:

4.3.2 Channel Response

Purpose

To verify the amplitude and group delay response of the channel.

Test Equipment

LO signal generator: HP Model 8341B, or equivalent. 940 to 2640 MHz
Vector network analyzer: HP Model 8753D, or equivalent. 800 to 2500 MHz

Setup

Connect the LO signal generator, the spectrum analyzer, the vector network analyzer, and the MP-2500 as illustrated in Figure 4-1. Set the instrument controls as follows:

LO Signal Generator

Frequency	940 MHz
Power	+13 dBm
Modulation	none

Network Analyzer

Center frequency	800 MHz
Span	10 MHz
Channel 1	Amplitude (S21)
Channel 2	Delay
Source power	+10 dBm

Ok. 2dBm.

Procedure

- ❒ 1. Normalize the amplitude and delay responses of the network analyzer before connecting the MP-2500 to the test circuit.
- ❒ 2. Insert the network analyzer into the test circuit as shown in Figure 4-1.
- ❒ 3. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*
- ❒ 4. Press *Start* (or *F3*) on the MP-2500 display.
- ❒ 5. Adjust the electrical length on the network analyzer until the average delay appears horizontal on the Channel 2 display. Format Delay SCALE ref / 1NS/div / Delay ≈ 3.0 MS.
- ❒ 6. Measure the amplitude response and group delay variation within the MP-2500 1 dB passband. TI (Path #1, Delay MS).

  Amplitude Ripple: _____ dB (Spec: 0.5 dB)

  Group Delay Variation: _____ nsec (Spec: ±30 nsec)
- ❒ 7. Record the total nominal electrical delay at 800 MHz.

  ≈ 3.0 MS. _____ µsec. (2.6 µsec, typical)

Tester:	Title:	Date:

4.3.3 VSWR

Purpose	To verify the RF input and output VSWR.
Test Equipment	LO signal generator: HP Model 8341B, or equivalent. 940 to 2640 MHz Vector network analyzer: HP Model 8753D, or equivalent. 800 to 2500 MHz
Setup	Connect the network analyzer and the MP-2500 as illustrated in Figure 4-1. Set the instrument controls as follows: *LO Signal Generator* Frequency 940 MHz Power +13 dBm Modulation none *Network Analyzer* Center frequency 800 MHz Span 6 MHz Channel 1 VSWR (S11) Source power +10 dBm
Procedure	❒ 1. Calibrate the network analyzer for VSWR before connecting the MP-2500 to the test circuit. ❒ 2. Connect the MP-2500 input to the network analyzer output. ❒ 3. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.* ❒ 4. Press *Start* (or *F3*) on the MP-2500 display. ❒ 5. Measure the MP-2500 input VSWR. _____ (Spec: 1.8:1) ❒ 6. Connect the analyzer to the MP-2500 RF output. ❒ 7. Measure the MP-2500 output VSWR. _____ (Spec: 1.5:1)

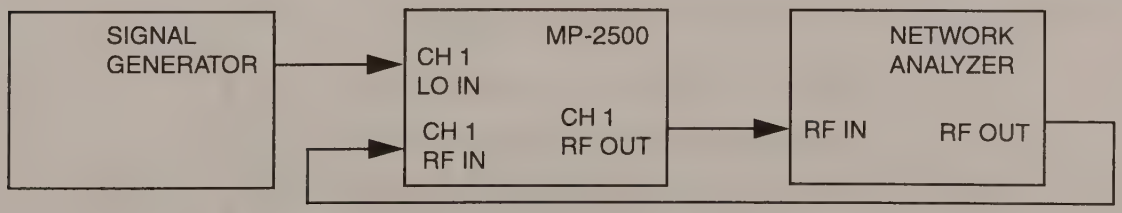


Figure 4-1. Network Analyzer Connections

Tester:	Title:	Date:

4.3.4 Statistical Distributions

4.3.4.1 Power Spectral Distribution

Purpose

To verify that the Rayleigh power spectral density distribution is correct.

Test Equipment

Spectrum analyzer: HP Model 8566B, or equivalent. 10 MHz to 3 GHz
RF signal generator: HP Model 8341B, or equivalent. 800 to 2500 MHz
LO signal generator: HP Model 8341B, or equivalent. 940 to 2640 MHz

Setup

Connect the RF signal generator, the LO signal generator, the spectrum analyzer, and the MP-2500 as illustrated in Figure 3-1. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	0 dBm	+13 dBm
Modulation	none	none

	Spectrum Analyzer
Center frequency	800 MHz
Span	2 kHz
Reference level	-25 dBm
Averaging:	
Steps 1-3	Off
Steps 4-10	On

Procedure

- ☐ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*
- ☐ 2. Modify Path 1 for a speed of 500 Km/hr and a Rayleigh spectrum.
- ☐ 3. Press *Start* (or *F3*) on the MP-2500 display.
- ☐ 4. Average the spectrum analyzer display for a minimum of 20 sweeps. (vid AVG on)
- ☐ 5. Observe amplitude spectrum peaking of 6 dB at the Doppler offset relative to the spectral density at the center frequency.
- ☐ 6. Observe that the spectrum is attenuated at least 30 dB at twice the Doppler offset.
- ☐ 7. Press *Reset* (or *F2*) on the MP-2500 display.
- ☐ 8. In the *Options* menu, select *Rayleigh Filter.*
- ☐ 9. In the *Rayleigh Filter Shape* dialog box, click on the down arrow to the right of the *Filter Selections* box.

(continued on next page)

Tester:	Title:	Date:

(continuation of 4.3.4.1 Power Spectral Distribution)

- ❒ 10. Select *shape4.flt* and press *Select*.
- ❒ 11. Restart *Averaging* on the spectrum analyzer and average the display for a minimum of 20 sweeps.
- ❒ 12. Observe that the signal spectrum has a rounded Gaussian shape.
- ❒ 13. Reset the filter shape to shape1.flt.

Tester:	Title:	Date:

4.3.4.2 Amplitude Probability Distribution

Purpose	To verify that the amplitude probability distribution is correct.
Test Equipment	Spectrum analyzer: HP Model 8566B. 10 MHz to 3 GHz RF signal generator: HP Model 8341B, or equivalent. 800 to 2500 MHz LO signal generator: HP Model 8341B, or equivalent. 940 to 2640 MHz IBM-compatible personal computer equipped with an IEEE interface.
Setup	Connect the RF signal generator, the LO signal generator, the spectrum analyzer, the IBM-compatible PC, and the MP-2500 as illustrated in Figure 4-2. Set the instrument controls as follows:

	RF Signal Generator	*LO Signal Generator*
Frequency	800 MHz	940 MHz
Power	0 dBm	+13 dBm
Modulation	none	none

	Spectrum Analyzer
Center frequency	800 MHz
Span	0 MHz
Vertical scale	Linear
Reference level	30 mv
Sweep speed	2 msec/div
Resolution BW	3 MHz

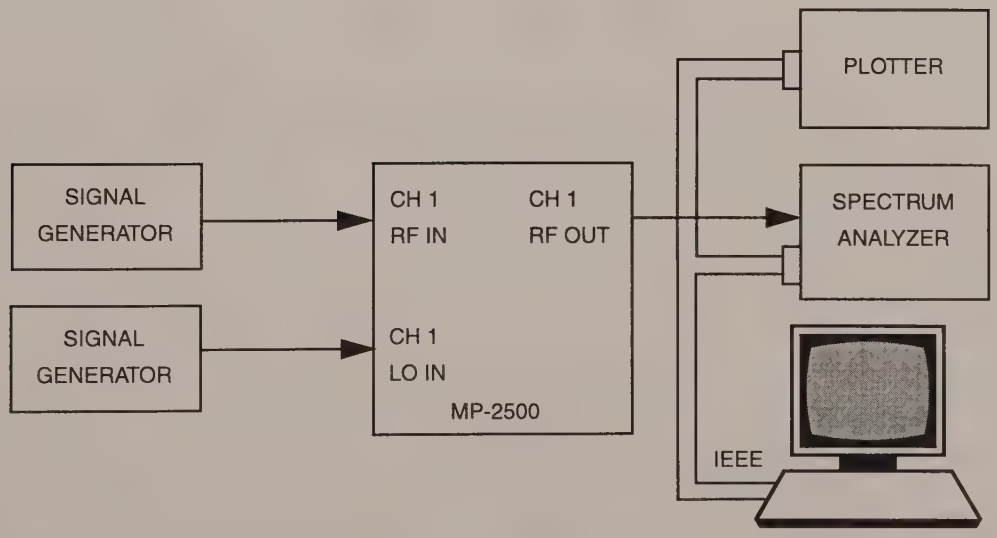


Figure 4-2. Computer Controlled Measurement Setup

Tester:	Title:	Date:

(continuation of 4.3.4.2 Amplitude Probability Distribution)

Program

To measure the amplitude probability distribution, it will be necessary to collect a large number of samples of the instantaneous output amplitude for a specified sampling interval. Load the *QuickBASIC* program listed below into the IBM-compatible personal computer to collect the amplitude data.

```
'$INCLUDE: 'QBDECL.BAS'
OPEN "GPIBO" FOR OUTPUT AS #1
OPEN "GPIBO" FOR INPUT AS #2
CLS
PRINT #1, "ABORT"
SLEEP 1
PRINT #1, "OUTPUT 18;B1"
PRINT #1, "OUTPUT 18;B3"

FOR I = 1 TO 200
     PRINT #1, "OUTPUT 18;A1;TS;"
     PRINT #1, "OUTPUT 18;A3;"
     PRINT #1, "OUTPUT 18;SMOOTH TRA,3;"
     PRINT #1, "OUTPUT 18;PDA TRB,TRA,.01;"
     PRINT "RUN NUMBER: ", I
NEXT I

     PRINT #1, "OUTPUT 18;A4;"

     END
```

Tester:	Title:	Date:

Procedure

(continuation of 4.3.4.2 Amplitude Probability Distribution)

- ❒ 1. Turn on the MP-2500 and load the *checkit.sta* file (if necessary) using the procedures outlined in Test 3.3.1 *Turn-On.*
- ❒ 2. For Path 1 select a Rayleigh spectrum and set *Speed* = 500 Km/hr.
- ❒ 3. Press *Start* (or *F3*) on the MP-2500 display.
- ❒ 4. Verify that the time varying amplitude of the signal is visible on the spectrum analyzer and that the signal trace does not exceed the top reference line. Adjust the analyzer reference, if necessary.
- ❒ 5. Start the control program on the IBM-compatible PC and let it run to completion.
- ❒ 6. The analyzer display represents the amplitude probability distribution. Plot the display and verify that it has the same general shape as the distribution in Figure 4-3a. Differences in the height of the distributions are not important.
- ❒ 7. Repeat Steps 3 through 6 for each of the following distributions. Compare the spectrum plots to the figures listed.

Log-Normal	4-3b
Rician	4-3c
Nakagami	4-3d

Tester:	Title:	Date:

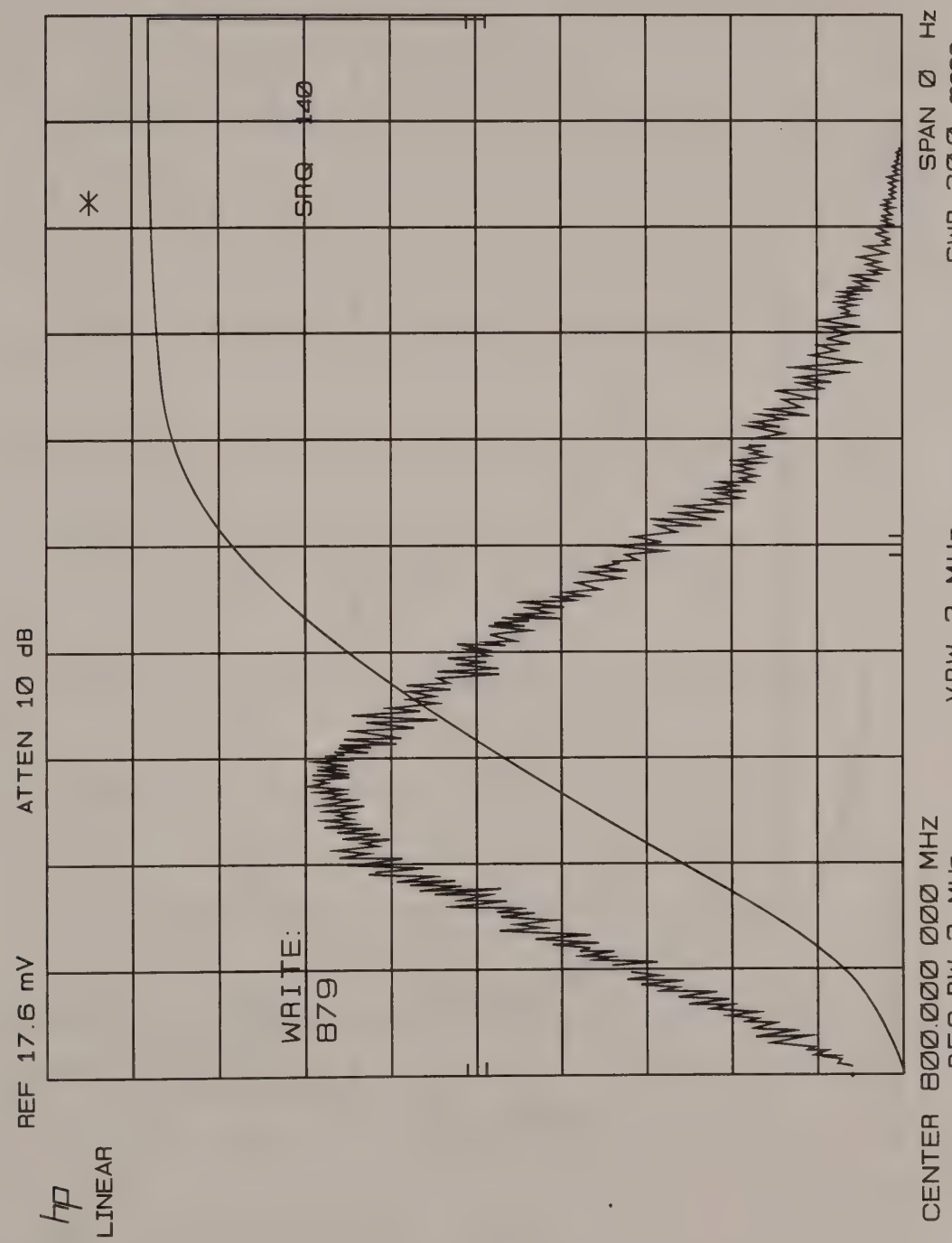


Figure 4.3a Amplitude Probability Distribution forRayleigh Spectrum

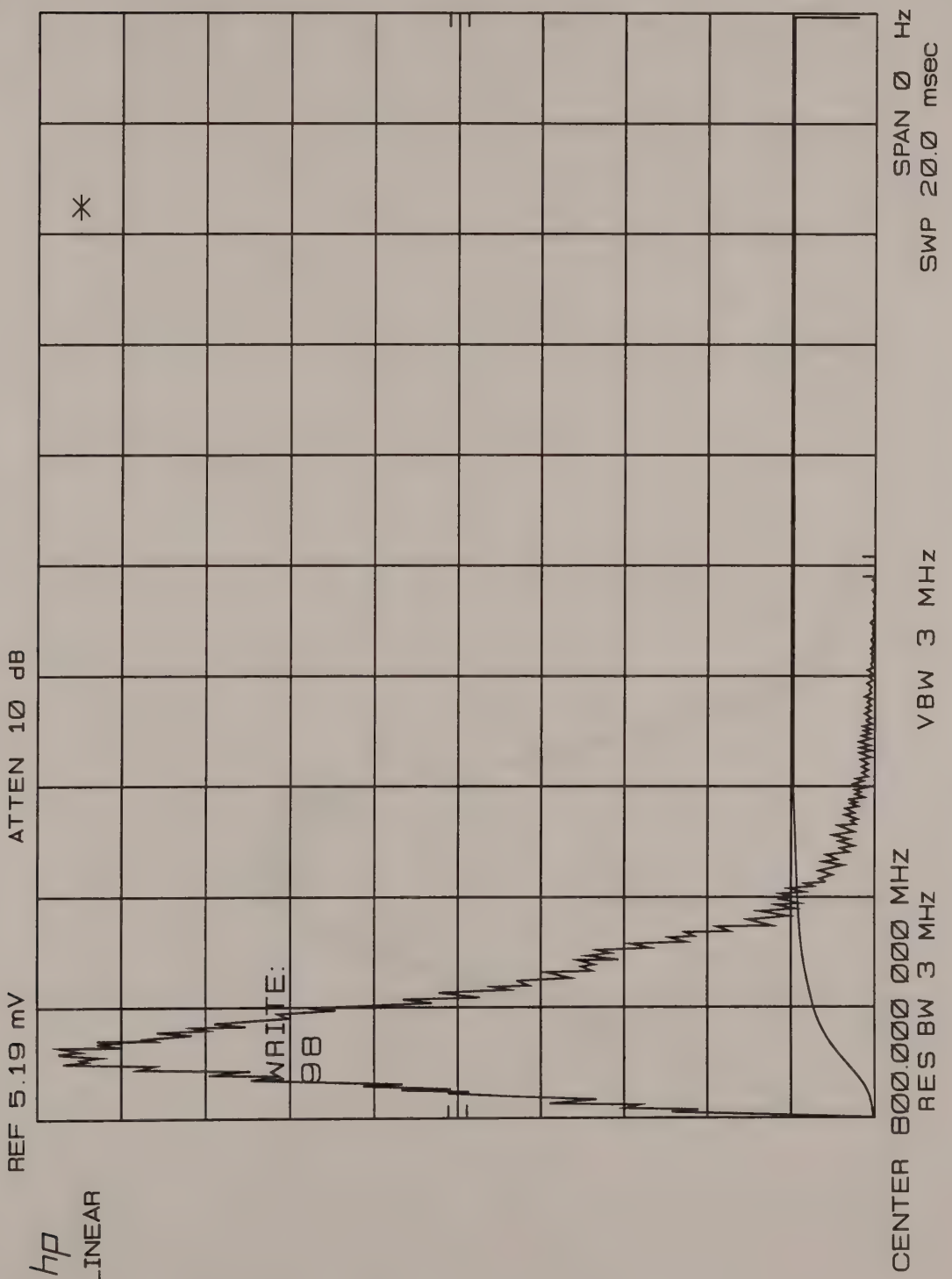


Figure 4.3b Amplitude Probability Distribution for Log-Normal Spectrum

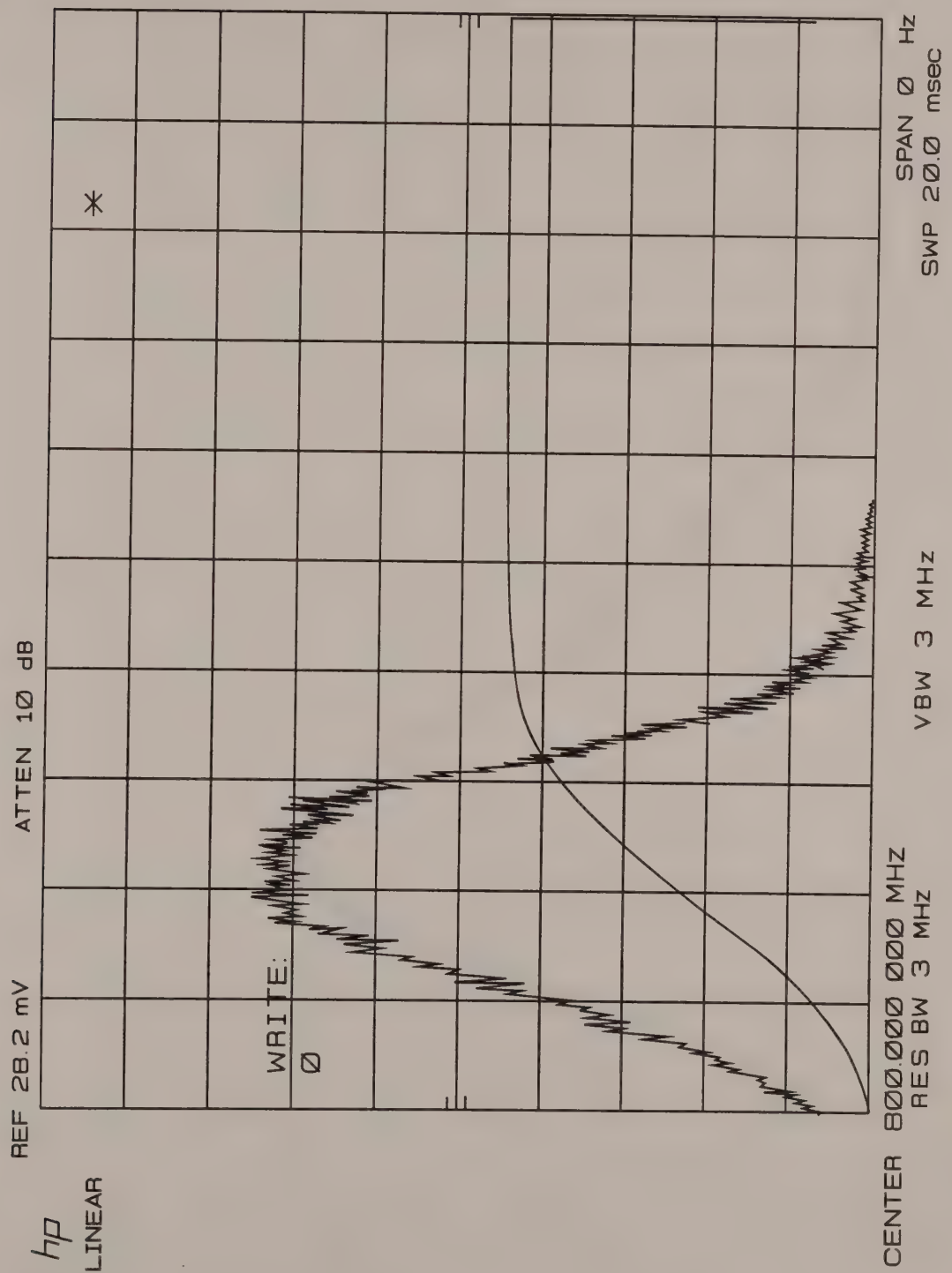


Figure 4.3c Amplitude Probability Distribution for Rician Spectrum

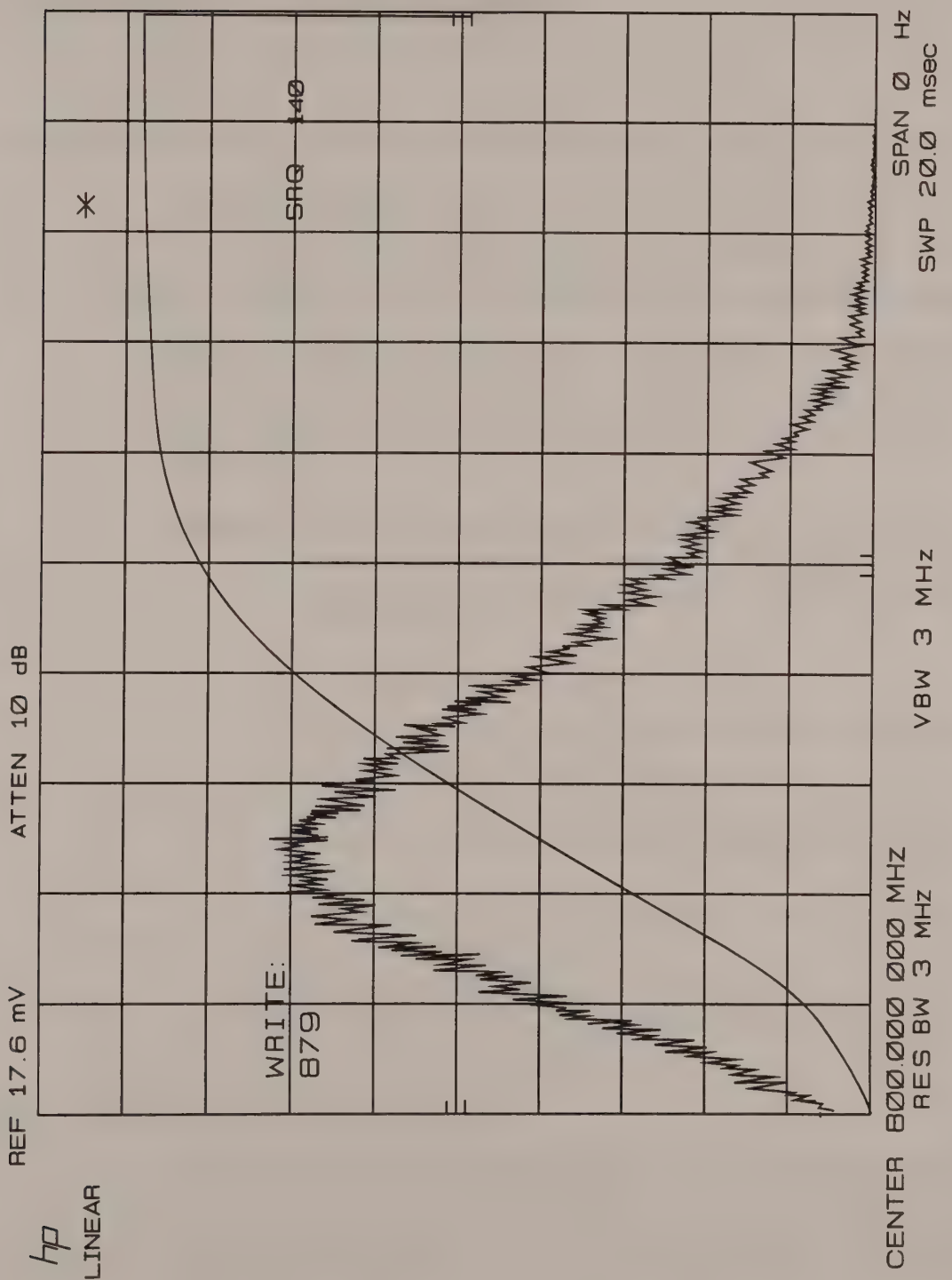


Figure 4.3d Amplitude Probability Distribution for Nakagami Spectrum

Section 5. Adjustments

The MP-2500 should not require adjustment over its lifetime. However, if adjustments are required, use the procedures described in this section.

5.1 Adjusting Output Power and Channel-to-Channel Power Balance

Each channel in the MP-2500 is adjusted to provide -29.8 ±1 dBm output power under the conditions defined in Operations Verification Procedure #3.3.2. The channel-to-channel output power balance is adjusted to within ±0.5 dB. If the balance is not adequate for your application, the following procedure can be used to improve it.

WARNING **Do not attempt to increase the output power above the maximum level specified in Section 2. Attempting to set output power above the specified maximum can degrade equipment performance.**

1. Remove the top and bottom covers.
2. Initialize the instrument using Operations Verification Procedure 3.3.2.
3. Use a power meter to measure the output power.
4. If you wish to optimize the output power at a frequency other than 800 MHz, set the RF signal and LO signal generators to the appropriate frequency.
5. Visually locate the two tracking YIG filters which are mounted behind the front panel near the bottom.
6. Remove the coaxial attenuator attached to the output connection of each filter (the RF OUT connector on the front panel).
7. Reassemble the instrument covers.

5.2 Adjusting Carrier Suppression

Each path in the MP-2500 has two adjustment potentiometers to optimize the carrier suppression of the single sideband modulation process. These potentiometers provide a very small DC offset to the modulation circuitry. High stability voltage references are used to generate this offset, and adjustment should not be required during the instrument lifetime. If adjustment is required, however, use the following procedure:

1. Remove the top and bottom covers.
2. Initialize the instrument using Operations Verification Procedure 3.3.2.
3. Adjust the speed of Path 1, Channel 1 to 900 km/hr.
4. Adjust the spectrum analyzer resolution to 2 MHz.

NOTE **The display will appear as a curve with small ripples. The carrier suppression is optimized when these ripples are minimized.**

5. Referring to Figure5-1, locate the potentiometer adjustments for Path 1 on the circuit board in Slot 5. The potentiometers are located toward the front of the instrument.
6. Adjust the potentiometers for Path 1 (J101 and J102) to reduce the displayed ripple. The adjustment is interactive and may require several iterations of each potentiometer adjustment to optimize the result.

NOTE **It may not be possible to eliminate the ripple completely. Generally, best performance is achieved when the ripple is minimized and has a sinusoidal appearance. Due to the sensitivity of the potentiometers, you should avoid turning them more than necessary.**

7. Repeat Steps 4 through 6 for each installed path.

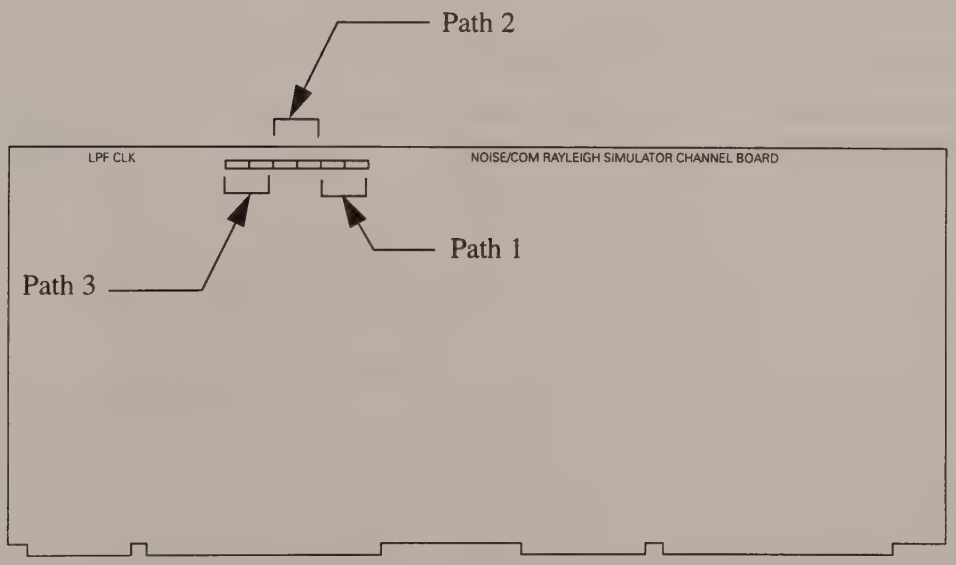


Figure 5-1: Adjustment Potentiometers on the Rayleigh Simulator Channel Board (Slot 5)

Section 6. Troubleshooting and Repair

6.1 Introduction

The following troubleshooting and repair procedures enable you to isolate and correct MP-2500 performance problems. Problems can either occur at turn-on or they can be related to RF performance during operation.

6.2 Trouble at Turn-On

6.2.1 Problem: Nothing happens when you turn on the MP-2500

Follow the procedures listed in Table 6.1.

Table 6-1: Troubleshooting Procedure 6.2.1

Step	Investigative Procedure	Expected Result	Corrective Action
1	Check the AC input voltage.	Voltage is between 94 and 264 VAC.	Adjust the AC input voltage to a value within the expected range.
2	Check the fuse (see Figure 6-1.)	Fuse is a 4 amp slow-blow type.	Replace the fuse if it is blown or damaged.
3	Verify power supply output voltages as follows: a. Remove the top cover. b. With the power switch on, measure the power supply output voltages by probing the large power connectors on top of the power supply filter assembly.	Wire Color — DC Volts Black 0 Red +5 ±0.2 White -5.2 ±0.2 Blue -12 ±0.3 Yellow +12 ±0.3	If any voltages are out of tolerance, replace the power supply.

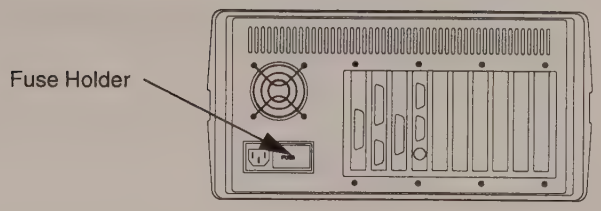


Figure 6-1. MP-2500 Rear Panel

6.2.2 Problem: Display indicates "CMOS CHECKSUM ERROR"

Proceed as follows:

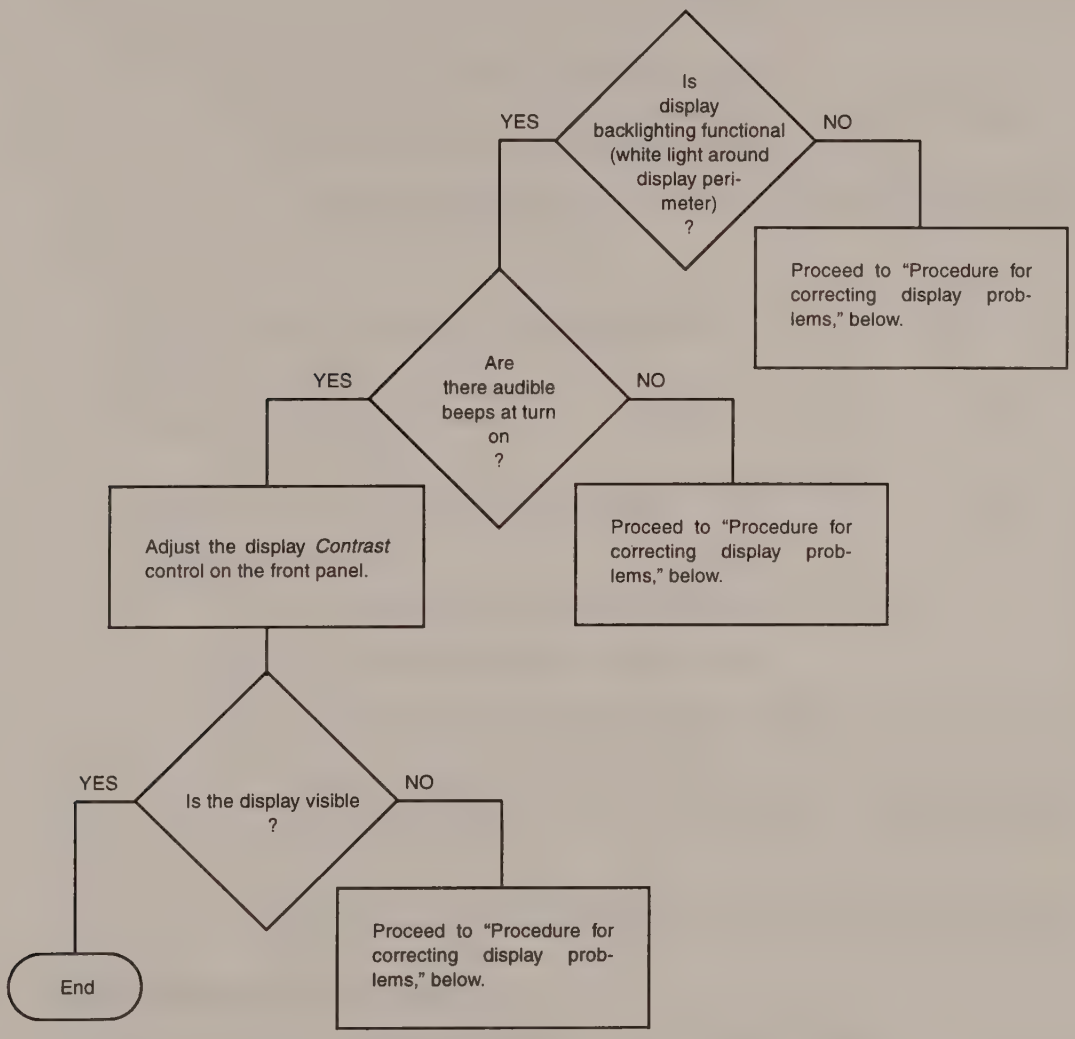
1. Turn off the MP-2500.
2. Turn on the MP-2500 and observe the display during the boot-up sequence.
3. When the line `press DEL for setup` appears, press the *Delete* key.
4. Press *Enter* at the first line in the menu (CMOS setup).
5. Press *Enter* a second time.
6. The displayed peripheral device table should read as follows:

Peripheral	Value
Floppy drive A:	3.5" 1.44 MB
Hard drive C:	User type 47
Display:	EGA/VGA
Keyboard:	Installed

7. If any value is not as shown above, use the ↓ key to move the flashing cursor to the faulty parameter.
8. Use the *PGUP* or *PGDN* key to modify the entry.
9. When you have corrected all anomalous values, press *ESC*.
10. Use the ↓ key to move to the line that reads `EXIT CMOS SETUP AND SAVE`.
11. Press *Enter*.
12. Type `y` at the prompt `Save new settings and exit?`
13. Reboot the MP-2500.

6.2.3 Problem: Display is not visible.

Proceed as follows:


Is display backlighting functional (white light around display perimeter) ?
YES
NO
Proceed to "Procedure for correcting display problems," below.
Are there audible beeps at turn on ?
YES
NO
Adjust the display *Contrast* control on the front panel.
Proceed to "Procedure for correcting display problems," below.
Is the display visible ?
YES
NO
End
Proceed to "Procedure for correcting display problems," below.

Procedure for correcting display problems.

1. Remove the top cover from the MP-2500.
2. Turn on the MP-2500 and reconfirm that the backlighting is visible around the perimeter of the instrument.

WARNING **The backlighting inverter produces high voltage. Do not touch it while power is applied to the MP-2500.**

3. Locate the display interface board that is attached to the back of the flat panel display.
4. Check the ribbon cables and connections on the board and on the display.
5. Locate the VGA driver board that is in Slot 2.
6. Check the ribbon cable and connector at the top edge of the board. Ensure that the connector is fully inserted.
7. If the cables are all secure and the display is inoperative, replace the display and display driver.

6.2.4 Problem: Keyboard or mouse is inoperative.

Proceed as follows:

Replace the keyboard or mouse.

6.2.5 Problem: Disk drive does not respond.

Proceed as follows:

1. Check CMOS setting using Procedure #6.2.2.
2. Remove the top cover from the MP-2500.
3. Check the power and control cables to the malfunctioning disk drive. Ensure that the power and control cables are fully inserted.
4. At the opposite end of the control cable (i.e., at the single board computer), verify that the connectors at the top edge of the computer board are fully inserted.
5. If Steps 1 through 4 do not correct the drive malfunction, replace the drive.

6.3 RF Performance Problems

RF performance problems are categorized into problems related to:

a. no output or low power output

b. distorted output

A. Problems Related to No Output or Low Power

6.3.1 No RF Output or Low Power from All Paths in Channel 1

Use the test configuration described in Procedure #3.3.2.

1. Verify that the program is running by observing that the elapsed timer is changing.

2. Verify that the RF input(s) are at the frequency indicated by the MP-2500 *Center Freq. (MHz)* parameter.
3. Verify that the RF inputs are connected to the correct ports and set at power levels within the specified range.
4. If any of the parameters examined in Steps 2 and 3 are incorrect, make the indicated correction and observe the RF output again.

If executing Steps 1 through 3 does not identify the cause of the RF output level problem, use the following procedures to isolate the cause. (It is not necessary to complete the steps remaining after the cause of the problem has been identified.)

5. Remove the top cover and inspect the location and condition of the RF interconnect cables. Compare the cable configuration with Figure 4-5 of the MP-2500 Technical Manual.
6. Check the DC voltage levels, using Procedure #6.2.1.
7. Disconnect cable W25 from J10 of U/D 1.
8. Verify the internal local oscillator performance by measuring the frequency and power of the LO signal on W25. The frequency should be 144.5 MHz, and the power should be approximately +12 dBm.
9. If the LO signal power or frequency are not as specified, replace the OSC module.
10. Reconnect W25.
11. Disconnect cable W14 from J1 of U/D 1.
12. Measure the power and frequency of the RF signal on W14. The frequency should be 800 MHz, and the power should be approximately -4 dBm.
13. If the RF signal power or frequency are not as specified, verify the integrity of cable W1 that connects the RF input to PD-1. Also verify that PD-1 is functioning properly.
14. Reconnect W14.
15. Disconnect cable W15 from J2 on U/D 1.
16. Measure the power and frequency of the LO signal on W15. The frequency should be 940 MHz, and the power should be approximately +7 dBm.
17. If either the LO signal power or frequency are not as specified, verify the integrity of cable W3 that connects the LO input to PD-2. Also verify that PD-2 is functioning properly.
18. Reconnect W15.

19. Disconnect cable W23 from J8 on U/D 1.
20. Measure the frequency and power of the signal at J8 on U/D 1. The frequency should be 4.5 MHz, and the power should be approximately +0.5 dBm.
21. Disconnect cable W24 from J9 on U/D 1.
22. Measure the frequency and power of the signal at J9 on U/D 1. The frequency should be 4.5 MHz, and the power should be approximately +0.5 dBm.
23. If either the LO signal power or frequency are not as specified, replace the U/D 1 assembly.
24. Reconnect W23 and W24.
25. Disconnect cable W22 from J7 on U/D 1.
26. Measure the frequency and power of the signal on W22. The frequency should be 4.5 MHz, and the power should be approximately -20 dBm. Note that this signal has a negative DC offset.
27. If either the power or frequency is not as specified, replace the DSP board in Slot 4.
28. Reconnect W22.
29. Disconnect cable W16 from J3 on U/D 1.
30. Measure the frequency and power of the signal at J3 on U/D 1. The frequency should be 800 MHz, and the power should be approximately -20 dBm.
31. If the power or frequency is not as specified, replace the U/D 1 assembly.
32. Verify the integrity of cable W16 that connects J3 on U/D 1 to YIG filter F-1. Also verify cable W2 that connects YIG F-1 to the Channel 1 RF Output connector.
33. If the cables are intact, replace YIG F-1 and the YIG driver on the OSC board.

6.3.2 No Output from Some of the Paths in Channel 1

1. If the defective paths are Paths 1, 2, or 3 (or any combination of these), replace the path board in Slot 5.
2. If the defective paths are Paths 4, 5, or 6 (or any combination of these), replace the path board in Slot 6.

6.3.3 No RF Output or Low Power from All Paths in Channel 2

Use the test configuration described in Procedure #3.3.2. Move the RF input, LO, and output cables to the Channel 2 connectors on the MP-2500 front panel.

1. Verify that the program is running by observing that the elapsed timer is changing.
2. Verify that the RF input(s) are at the frequency indicated by the MP-2500 *Center Freq. (MHz)* parameter.
3. Verify that the RF inputs are connected to the correct port and set at the correct power level.

If any of the parameters examined in Steps 2 and 3 are incorrect, make the indicated correction and observe the RF output again.

4. Remove the top cover and inspect the location and condition of the RF interconnect cables. Compare the cable configuration with Figure 4-5 of the MP-2500 Technical Manual.
5. Check the DC voltage levels, using Procedure #6.2.1.
6. Disconnect cable W28 from J10 of U/D 2.
7. Verify the internal local oscillator performance by measuring the frequency and power of the LO signal on W28. The frequency should be 144.5 MHz, and the power should be approximately +12 dBm.
8. If the LO signal power or frequency are not as specified, replace the OSC module.
9. Reconnect W28.
10. Disconnect cable W11 from J1 of U/D 2.
11. Measure the power and frequency of the RF signal on W11. The frequency should be 800 MHz, and the power should be approximately -4 dBm.
12. If the RF signal power or frequency are not as specified, verify the integrity of cable W1 that connects the RF input to PD-1. Also verify that PD-1, SW-1, and SW-2 are functioning properly.
13. Reconnect W11.
14. Disconnect cable W12 from J2 on U/D 2.
15. Measure the power and frequency of the LO signal on W12. The frequency should be 940 MHz, and the power should be approximately +7 dBm.

16. If the LO signal power or frequency are not as specified, verify the integrity of cable W3 that connects the LO input to PD-2. Also verify that PD-2, SW-3, and SW-4 are functioning properly.
17. Reconnect W12.
18. Disconnect cable W26 from J8 on U/D 2.
19. Measure the frequency and power of the signal at J8 on U/D 2. The frequency should be 4.5 MHz, and the power should be approximately +0.5 dBm.
20. Disconnect cable W27 from J9 on U/D 2.
21. Measure the frequency and power of the signal at J9 on U/D 2. The frequency should be 4.5 MHz, and the power should be approximately +0.5 dBm.
22. If the LO signal power or frequency are not as specified, replace the U/D 2 assembly.
23. Reconnect W26 and W27.
24. Disconnect cable W18 from J4 on U/D 1.
25. Measure the frequency and power of the signal on W18. The frequency should be 4.5 MHz, and the power should be approximately -20 dBm. Note that this signal has a negative DC offset.
26. If either the power or frequency is not as specified, replace the DSP board in Slot 7.
27. Reconnect W18.
28. Disconnect cable W17 from J6 on U/D 2.
29. Measure the frequency and power of the signal on W17. The frequency should be 4.5 MHz, and the power should be approximately -20 dBm. Note that this signal has a negative DC offset.
30. If either the power or frequency is not as specified, replace the U/D 1 assembly.
31. Reconnect W17
32. Disconnect cable W13 from J3 on U/D 2.
33. Measure the frequency and power of the signal on at J3 on U/D 2. The frequency should be 800 MHz, and the power should be approximately -20 dBm.
34. If either the power or frequency is not as specified, replace the U/D 2 assembly.
35. Reconnect W13.

36. Verify the integrity of cable W13 that connects J3 on U/D 2 to YIG filter F-2. Also verify cable W5 that connects YIG F-2 to the Channel 2 RF Output connector.
37. If the cables are intact, replace YIG F-2 and the YIG driver on the OSC board.

6.3.4 No Output from Some of the Paths in Channel 2

1. If the defective paths are Paths 1, 2, or 3 (or any combination of these), replace the path board in Slot 8.
2. If the defective paths are Paths 4, 5, or 6 (or any combination of these), replace the path board in Slot 9.

B. Problems Related to Distorted Output

6.3.5 Incorrect Output From All Paths in Channel 1.

1. If the output spectrum contains improper sidebands or exhibits other types of distortion within 1 MHz of the carrier, replace the DSP in Slot 4.
2. If the output power is too high, on U/D 1 disconnect cable W23 from J8 and disconnect cable W24 on J9.
3. Measure the frequency and power of the signal on the IF output at connectors J8 and J9 on U/D 1. For both signals, the frequency should be 4.5 MHz, and the power should be approximately +2 dBm.
4. If either the frequency or power level is incorrect on either connector, replace the U/D 1 assembly.
5. Reconnect cables W23 and W24.
6. Disconnect cable W22 from J7 on U/D 1.
7. Measure the frequency and power of the signal on W22. The frequency should be 4.5 MHz, and the power should be approximately -20 dBm. Note that this signal has a negative DC offset.
8. If either the power or frequency is not as specified, replace the DSP board in Slot 4.
9. Reconnect W22.
10. Disconnect cable W16 from J3 on U/D 1.
11. Measure the frequency and power of the signal at J3 on U/D 1. The frequency should be 800 MHz, and the power should be approximately -20 dBm.
12. If the power or frequency is not as specified, replace the U/D 1 assembly.

6.3.6 Incorrect Output from Some of the Paths in Channel 1

1. If the defective paths are Paths 1, 2, or 3 (or any combination of these), replace the path board in Slot 5.
2. If the defective paths are Paths 4, 5, or 6 (or any combination of these), replace the path board in Slot 6.

6.3.7 Incorrect Output from All Paths in Channel 2

1. If the output spectrum contains improper sidebands or exhibits other types of distortion within 1 MHz of the carrier, replace the DSP in Slot 7.
2. If the output power is too high, on U/D 2 disconnect cable W26 from J8 and disconnect cable W27 on J9.
3. Measure the frequency and power of the signal on the IF output at connectors J8 and J9 on U/D 2. For both signals, the frequency should be 4.5 MHz, and the power should be approximately +2 dBm.
4. If either the frequency or power level is incorrect on either connector, replace the U/D 2 assembly.
5. Reconnect cables W26 and W27.
6. Disconnect cable W18 from J4 on U/D 1.
7. Measure the frequency and power of the signal on W18. The frequency should be 4.5 MHz, and the power should be approximately -20 dBm. Note that this signal has a negative DC offset.
8. If either the power or frequency is not as specified, replace the DSP board in Slot 4.
9. Reconnect W18.
10. Disconnect cable W13 from J3 on U/D 2.
11. Measure the frequency and power of the signal at J3 on U/D 1. The frequency should be 800 MHz, and the power should be approximately -20 dBm.
12. If the power or frequency is not as specified, replace the U/D 2 assembly.

6.3.8 Incorrect Output from Some of the Paths in Channel 2

1. If the defective paths are Paths 1, 2, or 3 (or any combination of these), replace the path board in Slot 8.
2. If the defective paths are Paths 4, 5, or 6 (or any combination of these), replace the path board in Slot 9.

NOISE/COM

MP2500
Multipath Fading Emulator

Overview

Purpose of the MP2500

In wireless data communication systems, transmission impairments due to multipath fading, Doppler, and dispersive delay create inter-symbol interference, bit-errors, loss of synchronization, dropped calls, and busy signals. Precise emulation of wireless channels enables system designers and equipment manufacturers to perform repeatable tests in a laboratory environment. Tests that emulate multipath fading and Doppler can be used to verify the performance of a receiver or network, optimize channel thruput, enhance quality control, and support type acceptance procedures.

MP2500 Features

The MP2500 Multipath Fading Emulator simulates one or two wireless communication channels that can propagate over as many as 12 simulated signal paths. The MP2500 provides programmable delay, attenuation, frequency shift (Doppler), and a choice of Rayleigh, Rician, log-normal, Nakagami and Suzuki fading statistics for each path. Path parameters and selectable pre-stored industry standard propagation models (plus unlimited user-generated models) emulate hilly terrain, urban areas, rural areas, in-flight, and indoor environments. In the MP2500 Dynamic Mode, the channel propagation model is updated in real time according to the instantaneous position of the mobile transceiver.

The MP2500 includes a built-in 486DX/33 computer and a liquid crystal front panel display. A Windows-based graphical user interface simplifies setup and operation. An IEEE-488.2 interface is included for remote programming. The MP2500 is self-contained, modular, and expandable, in compliance with the Noise Com standard system architecture. The lifting handle and rugged carrying case enhance transportability.

Contents of this Technical Note

This Technical Note summarizes wireless channel emulation principles and describes the technical characteristics of the MP2500 system.

Applications

- Cellular Mobile Phone Systems
- Wireless Modem Testing
- Indoor Communications
- GSM
- CDMA
- AMPS
- TDMA
- PHS
- PCS-1900
- NADC
- DCS-1800
- CDPD
- Wireless LAN
- CT-2
- DECT
- Paging

Users

- Base Station Manufacturers
- Mobile Phone Manufacturers
- Telephone Company Network Simulation Labs
- System Integrators
- Wireless PCMCIA Data Modem & Semiconductor Design Engineers

Features

- Spurious-free output
- Built-in power meter
- 6 MHz RF bandwidth
- Up to 12 propagation paths
- Nakagami, Rayleigh, log-normal, Rician, and Suzuki distributions
- Programmable Doppler shift, attenuation, spectral distribution, and delay
- 1 ns delay resolution
- 12-bit real-time processing
- Low noise floor
- Output power levels from -100 to -19 dBm (-13 dBm optional)
- Optional synthesized LO
- Able to import realistic terrain models

Wireless Channel Emulation

Multipath Models

A wireless communication channel is modeled as a nearly infinite sum of delayed and attenuated replicas (echoes) of the transmitted signal. These echoes are caused by reflection, refraction, and scattering of the original signal by natural and manmade objects, such as the ground, mountains, buildings, or walls.

Phase distributions. Only one path, the direct path (if it exists), exhibits frequency shift (pure Doppler) without frequency spreading. The relative phases of the reflected and scattered waves are randomly distributed according to the reflector characteristics and changes in the refraction index of the air. When the reflecting structure is larger than one wavelength (1/frequency), the phases of the reflected signals are uniformly distributed between 0 and 360 degrees.

Amplitude distributions. According to the central limit theorem, if all the reflected signals are of approximately the same amplitude, their sum has in-phase (I) and quadrature (Q) components that follow normal Gaussian distributions. In this idealized case, the amplitude envelope has a Rayleigh distribution. However, actual reflected signals do not have equal amplitudes and realistic amplitude envelopes are Nakagami distributed.

The combination of one Doppler shifted path and one or more Rayleigh faded paths produces Rician fading. A more realistic fading model may be realized by using the Doppler mode for the direct path and Nakagami distributions for the other paths.

The Dynamic Channel

Each time a signal is reflected or attenuated, its amplitude is reduced equivalent to a multiplication by a reflection coefficient or attenuation factor between 0 and 1. If the signal undergoes many reflections and attenuations (e.g., as it passes through walls or trees) and if the reflection coefficients and attenuation factors are of approximately the same magnitude, the resulting multiplications result in a log-normal distribution, according to the central limit theorem.

A signal with a log-normal amplitude distribution (commonly referred to as shadowing) exhibits a slow variation of average signal power, since the environment or the position of the mobile must change dramatically to change the number of reflections or attenuations. A log-normal distribution may be overlaid on the Rayleigh distribution to generate a Suzuki fading model. The Suzuki fading model seems to be the most realistic available for dynamic environments.

Emulation Strategies

Experiments show that emulations of signal echoes that have average power levels in the range from 0 to 30 dB below the strongest signal provide almost perfect models (i.e., the number of lost calls, disconnects, and the bit and frame error rates accurately portray the "real world"). Emulating only the paths with 0 to 20 dB relative average power provides usable models as well.

Models of rural areas contain approximately five paths between 0 and 20 dB. Hilly terrain, urban, and indoor areas typically require ten or more paths with relative average power levels between 0 and 20 dB. Omitting any of these paths in simulations causes the temporal characteristics of the model to deviate significantly from the actual.

Emulation Accuracy

Output Power Setting. Setting the channel output power requires that the output power measurements be sufficiently accurate to make useful adjustments. Fading signals, however, are difficult to measure. Because of the signal power variations, it may be necessary to average the measurement data over intervals as long as 15 minutes when the Doppler frequency (hence the fading rate) is relatively low. Additionally, for the measurement to be meaningful, the measured signal must be free of spurious, images and local oscillator (LO) feedthrough.

These considerations are incorporated into the MP2500 design, which:

- includes output signals that are free of undesired components
- uses the selected fading statistics to weight power measurements.

Spurious signals. To ensure measurement accuracy, the emulator output signal image and LO feedthrough must be suppressed within the 12- to 15-MHz band centered on the output signal. Otherwise these products will pass the front-end filters of the receiver under test (without attenuation) and generate harmonics and sum and difference products of the image and LO signals in the first mixer. Especially difficult to suppress is the second harmonic of the LO feedthrough minus the image because its frequency is equal to the frequency of the desired signal.

Depending on the relative phase and amplitude of the receiver under test and the channel emulator, the image product may either cancel the desired signal or double its power. This creates an uncertainty in received signal strength and frame error rate (FER).

The MP2500 incorporates precision superheterodyne conversion and filtering techniques to prevent these spurious signals from degrading measurement results. Careful design of mixing frequencies and filter characteristics suppresses undesired products at least 60 dB below the output signal level in all paths and at all power levels.

CDMA Base Station and Mobile Station Testing

The MP2500 standard channel simulator supports the channel model parameters and characteristics listed in IS-97 and IS-98 for the CDMA Soft Hand-off application. (**Figure 1**). Note that if the true error rate is close to the specified error rate, the test time can be lengthy. At 20 ms per frame, a few thousand seconds of testing may be required to achieve the desired confidence level. During the test, the fading emulation should not be repeated.

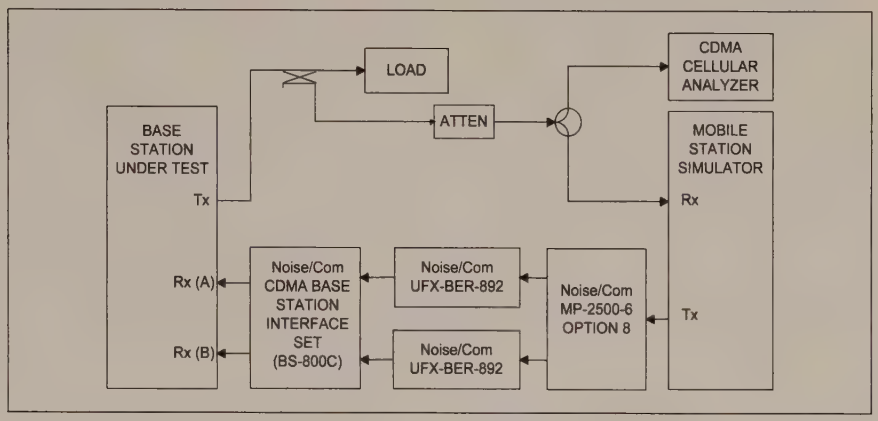


Fig 1. CDMA Soft Hand-off test setup

GSM Adjacent Channel or Interferer Application for Type Acceptance Preparations

The MP200-12 equipped with Option 8 (synthesized LO) enables the user to select between 6-path C/I (**Figure 2**) and 12-path single channel (**Figure 3**) configurations, according to GSM 05.05. The synthesized LO meets the phase noise requirement for GSM. Extended delays (432 or 864 ms) for extended-range GSM (e.g., Australia) are optionally available. The standard RF input range of 800 to 2500 MHz covers both the 900 MHz DCS-1800 and PCS-1900 frequencies with 12 paths in one unit. Operations below 800 MHz may be accomplished by bypassing the tracking filter.

Indoor Wireless Applications

Because of its ability to provide up to 12 paths of Suzuki fading with extremely short differential delays, the MP2500-12 can accurately emulate indoor channels for wireless LAN, wireless PBX, and cordless telephone applications.

Short delays translate into high spatial resolution. For example, 1 nanosecond equates to 1 foot (0.3 m). High resolution assures that an object's location can be emulated accurately.

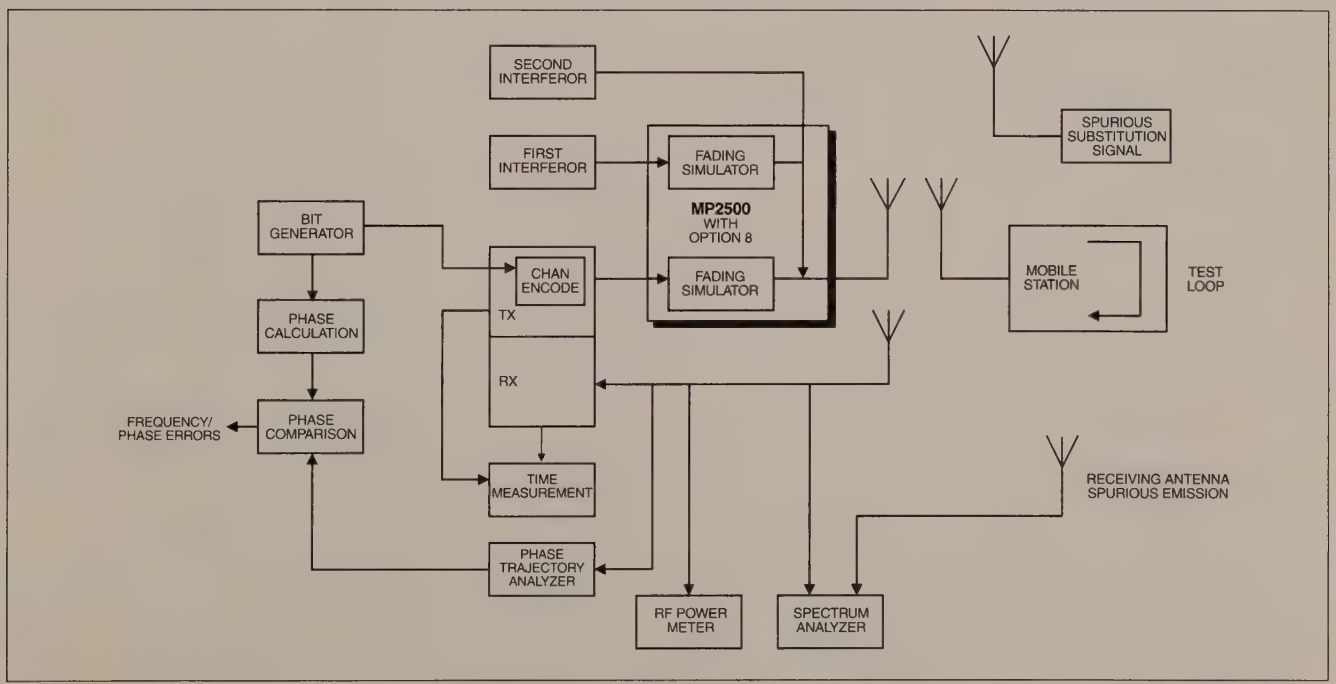


Fig 2. C/I test setup

Published measurements of indoor communication channels indicate that many paths are required for accurate emulation. Models requiring 12 paths can be run using one MP2500-12. The Suzuki distribution combines the features of the log-normal and Rayleigh models. The Rayleigh model simulates the scattering or normal distribution of each of the X- and the Y-axis coordinates of a reflector. The log-normal distribution accounts for the variations due to people moving around within the building. The Suzuki distribution enables continuous transformation between indoor and outdoor models.

DECT and PHS Testing

Both Digital European Cordless Telephone (DECT) and Personal Handyphone System (PHS) for digital cordless telephone applications can be tested using the MP2500 equipped with the duplexer option, as illustrated in **Figure 4**.

Diversity Testing

Two channels are required for testing diversity receiver functions (**Figure 5**). With one RF test signal traveling through different paths, the two independent outputs are combined at the receiver (DUT) for diversity testing. Note that only one synthesized LO (Option 8) is required for upconverting/down-converting the RF input signal.

Combined Diversity and Interference Testing

One MP2500-12 can be used for combined interference and diversity testing (**Figure 6**). Each channel can be divided into groups of three paths, and the output can be combined within the MP2500-12 before it is applied to the DUT. Only one synthesized LO (Option 8) is required for this setup (specify when ordering).

Duplex Testing

Full duplex testing can be performed with two MP2500 units for combined interference or handoff testing (**Figure 7**).

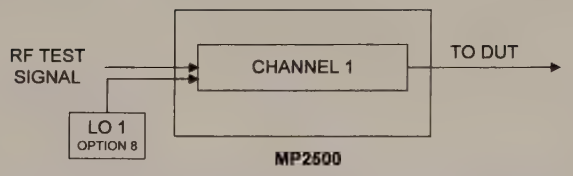


Fig 3. Single channel configuration with up to 12 paths per channel

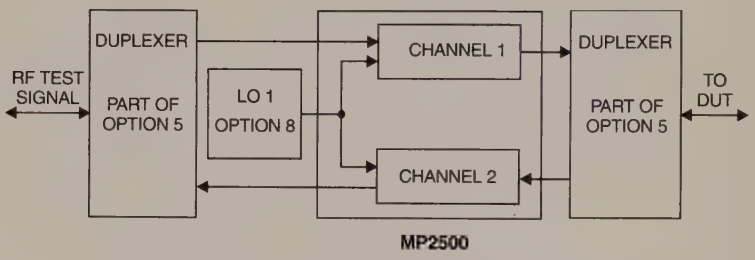


Fig 4. Test configuration for DECT and PHS testing

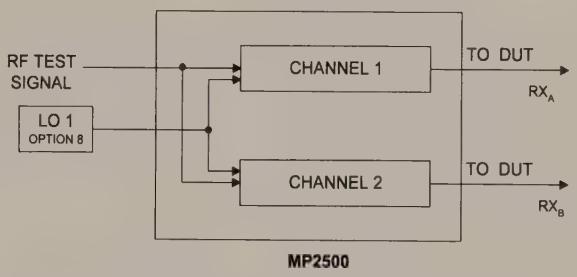


Fig 5. Diversity test configuration with one LO controlling two channels

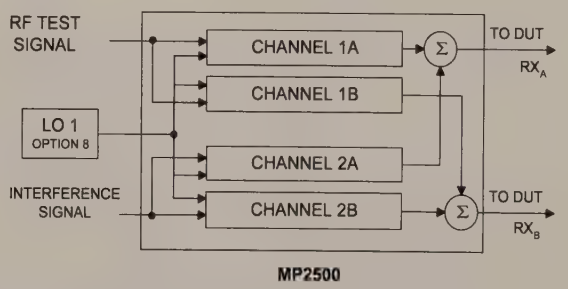


Fig 6. Diversity and interference test with MP2500-12 (optional setup)

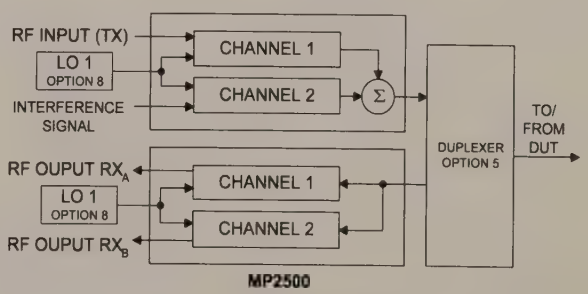


Fig 7. Duplex operation with interference or handoff

Equipment Features

Built-in computer. The MP2500 contains a single-board 486DX/33 computer on the passive Industry Standard Architecture (ISA) motherboard. The computer includes a mouse port, serial port, and parallel port. A video graphics adaptor (VGA) driver board can simultaneously drive an external VGA display and the liquid crystal display (LCD) color display mounted on the front panel. The MP2500 has an IEEE-488.2 interface that includes hardware, software drivers, and configuration and debug files. A detachable 88-key keyboard and a mouse are included.

MP-2500 software. The following preinstalled software is provided:

- DOS 5.0
- Microsoft Windows 3.1.
- The MP2500 application program.
- Files for performing GSM and DCS testing per GSM.05.05-DCS, TDMA per IS-55/56, and CDMA per IS-97/98.
- Basic and C drivers for controlling the IEEE-488.2 interface in DOS or Windows.

All MP2500 software can be easily upgraded in the field by loading new files from a floppy disk.

Graphical User Interface. The Windows-based graphical user interface simplifies MP2500 operation. Figure 8 illustrates the parameter table for the MP2500 Static mode. All controls are operated using the keyboard, mouse, or IEEE-488.2 (remote) interface. The user sets the desired parameters into each path. Industry standard models emulating hilly terrain, urban area, rural area, in-flight, and indoor environments are prestored and can be recalled readily. Standard test conditions for GSM, DCS, AMPS, NADC/CDMA, and other applications are factory stored. These and any number of user-generated models can be saved as files on the internal hard disk or floppy disk drive. Path parameters can be modified in real time without halting a test in progress.

Dynamic (Map) Mode. The Dynamic mode illustrated in **Figure 9** provides the user with a two-dimensional simulation of a mobile transceiver, one or two base stations, a shadow, and up to eleven reflected signal paths. Each reflector is characterized as a statistical or pure Doppler reflector, with an assigned reflection coefficient and position. The base stations, the mobile transceiver and its travel path, the shadow, and the reflectors can be positioned anywhere on

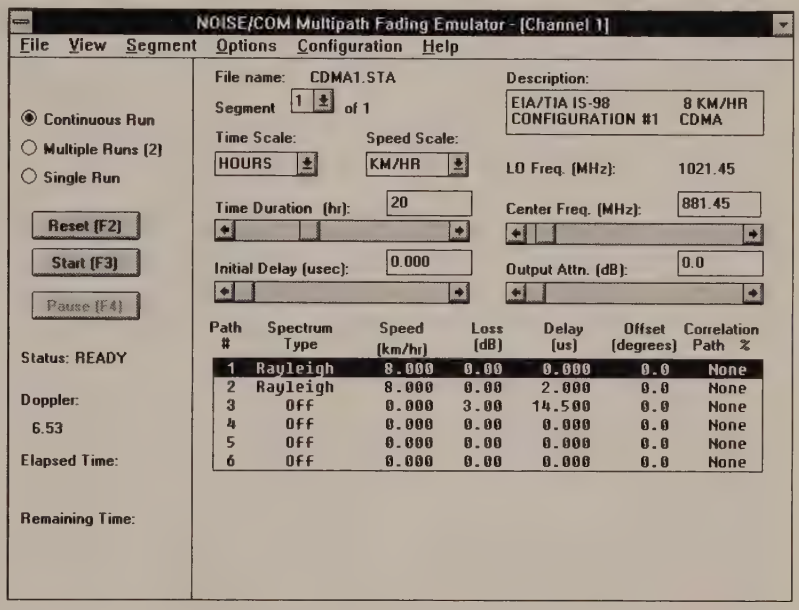

NOISE/COM Multipath Fading Emulator - [Channel 1]
File View Segment Options Configuration Help
Continuous Run
Multiple Runs (2)
Single Run
Reset (F2)
Start (F3)
Pause (F4)
Status: READY
Doppler:
6.53
Elapsed Time:
Remaining Time:
File name: CDMA1.STA
Segment 1 of 1
Description:
EIA/TIA IS-98 8 KM/HR
CONFIGURATION #1 CDMA
Time Scale: HOURS
Speed Scale: KM/HR
LO Freq. (MHz): 1021.45
Time Duration (hr): 20
Center Freq. (MHz): 881.45
Initial Delay (usec): 0.000
Output Attn. (dB): 0.0
Path # Spectrum Type Speed (km/hr) Loss (dB) Delay (us) Offset (degrees) Correlation Path %
1 Rayleigh 8.000 0.00 0.000 0.0 None
2 Rayleigh 8.000 0.00 2.000 0.0 None
3 Off 0.000 3.00 14.500 0.0 None
4 Off 0.000 0.00 0.000 0.0 None
5 Off 0.000 0.00 0.000 0.0 None
6 Off 0.000 0.00 0.000 0.0 None

Fig 8. Static mode parameter table

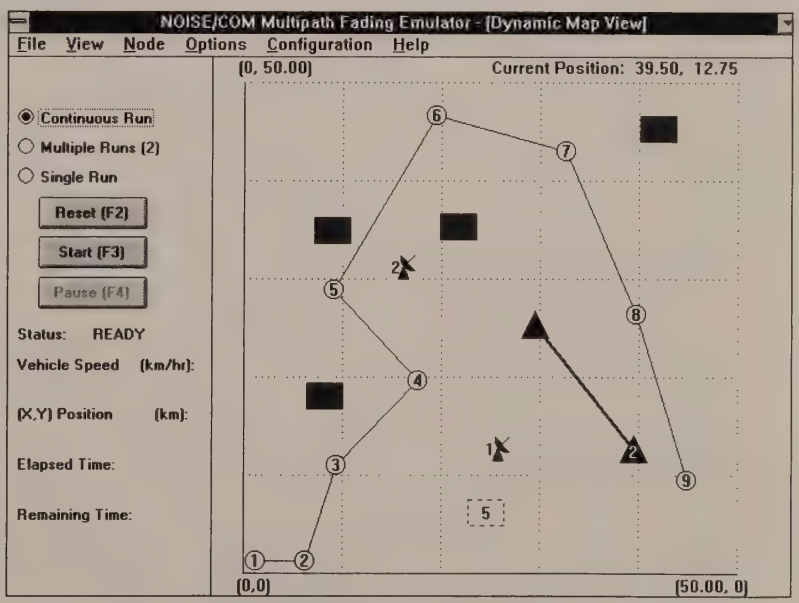


Fig 9. Dynamic simulation map

the map. The map scale and units of distance are programmable.

Based on the physical position of one or two base stations, a mobile transceiver, numerous reflectors and an obstruction, the MP2500 generates the fading characteristics which result from the user entries. On the map view, the mobile position and the path parameters are displayed in real time. Input signal processing begins when the *Start* key is pressed. Updates of vehicle speed, path length, and angle of arrival occur 10 times a second. Shadowing can be programmed onto the Dynamic map to generate slow fading of the direct path. Durations and depths of slow fades are based on the size and positioning of the object causing the shadow.

Spurious and image suppression. The MP2500 output is clean and spurious-free. Because most wireless communication systems receive and transmit in 25 MHz bands that are separated by 45 MHz, spurious signals that fall within the receive band can cause saturation, intermodulation, and changes in AGC operating level. These can invalidate test results.

Images of the desired signal can either increase or decrease the received signal-to-noise ratio (SNR). Since it is difficult to predict whether the presence of the image and spurious signals will enhance or degrade device performance, the MP2500 eliminates image, spurious, and local oscillator leakage signals through the use of precision superheterodyne conversion.

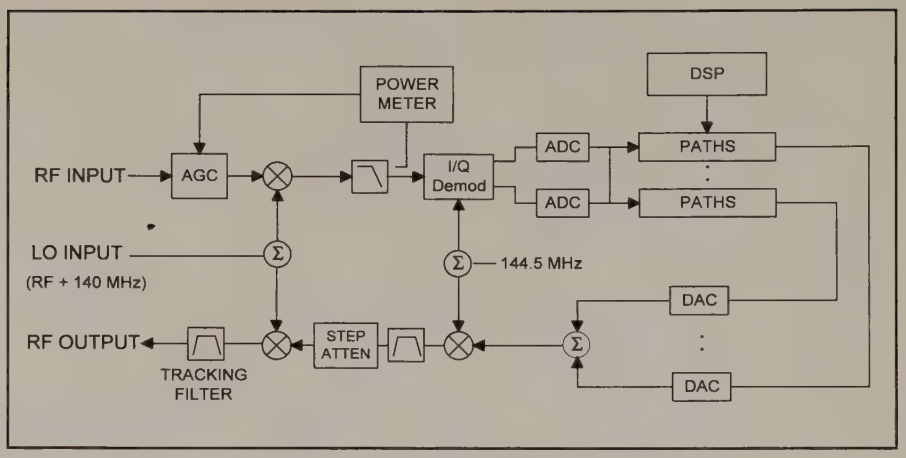


Fig 10. MP2500 simplified block diagram

Block Diagram Description

Input signals in the frequency range from 800 to 2500 MHz (or in optional bands from 30 to 6000 MHz) are applied to the down converter and translated to the 140 MHz frequency of the I/Q demodulator (**Figure 10**). The I- and Q-channel outputs from the demodulator are digitized and distributed to each of the equipped signal paths (3 to 12 paths are available).

A built-in power meter and AGC circuitry maintain optimal signal-to-noise ratios into the 12-bit A/D converters (ADCs). In each path, the I and Q signals are applied to a vector modulator which multiplies the signals by shaped statistical distributions. Each distribution is pre-shaped by a 256-tap user-programmable FIR filter (**Figure 11**).

The I and Q signals are combined to form the desired Doppler shifted, faded signal in each path.These signals are each delayed and attenuated according to user-selected values and converted to analog format.

The analog signals are combined to produce a composite signal which is initially converted to an IF of 140 MHz and applied to a surface acoustic wave (SAW) filter. The filter eliminates the LO and the image frequencies. In the final conversion, the 140 MHz IF signal is translated to the RF frequency. A tracking filter excludes the image and second LO frequencies, which are separated by 140 and 280 MHz, respectively, from the RF signal. The result is a clean, spurious-free output that contains only the desired RF signal.

Signal routing networks at the input and output of the MP2500-6 and MP2500-12 models enable the channel configuration to be selected by the user through software control. The LO applied to Channel 1 can be shared by Channel 2, eliminating the need for a second external LO (**Figures 4 through 7**). The RF input signal can also be routed to Channel 2 for 12-path single-channel testing (**Figure 6**) or diversity testing (**Figure 5**). The output of both channels can be combined to simulate handoff, co-channel and adjacent channel interference (**Figure 7**). Alternatively, the two channels can be operated independently for forward and reverse link testing (**Figure 4**).

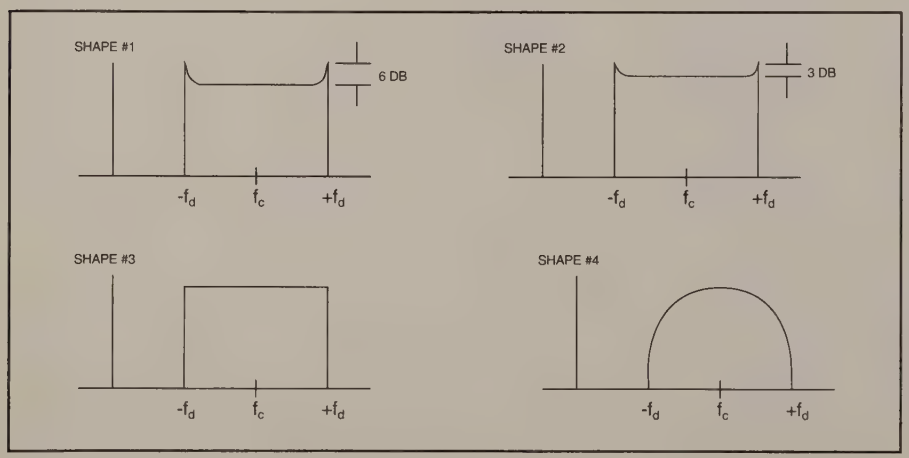


Fig 11. Filter shapes

Specifications

Base Unit Specifications

Number of independent RF channels	2
RF input/output connectors	SMA female, 50 ohms
Input VSWR	1.8:1, maximum
RF input level (automatic gain control sets peak power to optimum level)	
Baseline	- 10 to +20 dBm at SNR = 54 dB - 64 to +20 dBm at SNR > 0 dB
Option	+13 to +43 dBm at SNR = 54 dB
Absolute max. level	+23 dBm
RF output power range	-19 to - 100 dBm
Max. reverse input power	+20 dBm
RF frequency range	
Baseline	800 to 2500 MHz
Option	30 to 6000 MHz (in bands)
RF bandwidth (3 dB)	6.0 MHz min.
Group delay variation	±30 ns in 1 dB bandwidth, typical
Path insertion loss	12 to 140 dB
Insertion loss variation (path-path)	±0.1 dB
Residual channel delay	2.6 µs, typical
Path-to-path insertion delay variation	±5 ns, maximum
LO input frequency range	RF frequency plus 140 MHz
LO input level	+13 dBm
LO feedthrough on RF output	-75 dBm typical
Image feedthrough on RF output	-60 dBc maximum
Path on/off ratio	65 dB
Path RF out S/N ratio	54 dB per 6 MHz bandwidth
RFout spurious levels	-55 dBc
Number of paths	User programmable up to 12 (MP2500-12)
Path modulation	Nakagami, Rayleigh, Delay, Doppler frequency shift, Phase shift, Rician, Suzuki, and Log-Normal shadowing
Path attenuation range	0 to 30 dB
Path attenuation resolution	0.017 dB
Path attenuation accuracy	±0.2 dB
Path amplitude ripple	±0.2 dB from best fit straight line
Relative delay between paths	0 to 216 µs
Relative delay resolution	1 ns
Relative delay units	µs
Relative delay accuracy	2 to 5 ns typical
Simulated vehicle speed range	0 to ±935 km/h at 900 MHz RF
Simulated vehicle speed resolution	0.0156%
Simulated vehicle speed units	m/s, km/h, ft./s, and miles/hr.
Simulated Doppler range	
Baseline	0 to ±780 Hz
Option	0 to ±1560 Hz
Doppler resolution	0.0156%
Doppler stability	50 ppm
Doppler accuracy	<1%, IS-97 and IS-98
Rayleigh distribution	
Repetition interval	Programmable up to 24 hours
Deviation from CPDF	±0.5 dB from -25 to +10 dB
Level crossing rate accuracy	±2.5%
Path-to-path correlation	0 to 100% between any paths
Correlation resolution	1%
Relative phase range	0 to ±360^{o}
Relative phase resolution	0.1^{o}
Instrument safety	UL-1244, CSA 231, IEC-1010-1
Operating temperature range	0 to +50^{o}C
Storage temperature range	-30 to +65^{o}C
Humidity (operating)	95%
EMC	EN 55011, Group 1, Class A
Power, primary	
Voltage	90 - 264 VAC, autoranging
Frequency	48 - 66 Hz
Consumption	300 VA, maximum
Weight	16.5 kg (36 lbs.), typical
Dimensions	17.9" D x 14.3" W x 7.8" H (45.5 cm D x 36.4 cm W x 19.7cm H)

Built-in processor and peripherals

486DX/33 MHz	4 MB RAM	420 MB hard drive
3.5" floppy drive	VGA display	IEEE-488.2 interface
Parallel/printer port	Serial port	88-key keyboard + mouse

Specifications subject to change without notice.

Specifications for Optional Equipment

High power attenuator (Option 4)

Frequency range	DC to 8 GHz
Nominal attenuation	20 ±0.3 dB
Maximum VSWR	1.20:1 into 50 ohms
Power rating	25 watts (average) to 25°C
Connectors	Type N female

Duplexer (Option 5)

Frequency range	800 to 1300 MHz and 1300 to 2500 MHz
Isolation	15 dB minimum, 20 dB typical
Insertion loss	1 dB maximum
VSWR	1.5:1 maximum
Connectors	Type N female at duplex ports SMA female at uni-direction ports
Dimensions	14.5" W x 4.75" H x 16.75" D (36.8 cm W x 12.06 cm H x 42.55 cm D)

Synthesized LO (Option 8)

LO output frequency range	960 to 2640 MHz
LO output frequency resolution	1 MHz
LO output level	+10 dBm minimum
Phase jitter	<1° RMS, 10 Hz to 100 kHz, SSB
Power at sample output	-20 dBm typical
Spurious outputs	-60 dBc @ F_C ±10 MHz
Harmonics	-10 dBc maximum
Power consumption	250 watts per synthesizer
Input line voltage	Selectable from 100 VAC to 240 VAC, 50-60Hz
Dimensions	14.5" W x 4.75" H x 16.75" D (36.8 cm W x 12.06 cm H x 42.55 cm D)

Ordering Information

Model Numbers and Applications

Model No.	Number of Paths per Channel	Application
MP2500-3	One channel with 3 paths	CDMA with MP2500-6
MP2500-6	Two channels with 3 paths each or one channel with 6 paths	CDMA (IS-97/98), TDMA (IS-55/56)
MP2500-12	Two channels with 6 paths each or one channel with 12 paths	GSM, DCS1800, and indoor wireless

Options and Optional Configurations

Options	Description
1	Upgrade from MP2500-3 to MP2500-6.
2	Upgrade from MP2500-6 to MP2500-12.
3	19" rack mount. Includes brackets and front plate. Not available with option 6.
4	External input attenuator. Changes input power range to +13 to +43 dBm.
5	Dual duplex interface. 800 - 2500 MHz
6	18" wide chassis with 4 additional ISA slots instead of standard 14" chassis. Available with initial order, only.
7	Frequency range. Several frequency ranges in the bands between 2 MHz and 6 GHz are available. Consult factory.
8	Synthesized local oscillator. Consult factory for frequency coverages. Includes option 6.

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